ACROSS ATLANTIC ICE

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ACROSS ATLANTIC ICE

The Origin of America's Clovis Culture

Dennis J. Stanford
Bruce A. Bradley

Foreword by Michael B. Collins

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PREHISTORIC TIME LINE

11,700–present years BP	Holocene
12,500–11,000 years BP	Post-Clovis fluted and unfluted (Late Paleo-American) culture
12,800–11,500 years BP	Younger Dryas
13,200–12,500 years BP	Clovis (Middle Paleo-American) culture
13,500–11,000 years BP	Nenana-Denali (Beringian Paleo-American) culture
14,700–12,700 years BP	Bølling interstadial
16,800–13,200 years BP	Proto-Clovis (Southeast Early Paleo-American) culture
24,000–16,800 years BP	Mid-Atlantic Early Paleo-American culture
24,500–18,000 years BP	French and Northern Spanish Solutrean culture
25,000–13,000 years BP	Last Glacial Maximum (LGM)
110,000 years ago to present	Last glacial period
2.58 million years BP	Pliocene-Quaternary (current ice age) glaciation began

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FOREWORD

Across Atlantic Ice is an account of two complex and treacherous journeys, one long ago and the other very recent. One is postulated to have occurred across a perilous mosaic of periglacial environments of the Northern Hemisphere during the peak of the last major glaciation some eighteen or twenty millennia ago. The other is a twenty-year intellectual excursion far outside the academic mainstream by two scholars to explore possible answers to the questions of who first came to the Americas, when, whence, and how.

We long thought that we knew the story of the initial peopling of the Americas: Nomadic mammoth hunters moved out of the Russian steppe, across the ice age Bering land bridge, down an ice-free corridor between the major ice sheets of Canada, and onto the northern Great Plains. This brought them to an American Serengeti of giant bison, mammoth, mastodon, horse, camel, and many other worthy game animals. Once in America some 13,500 years ago, these big game hunters coined a new technology, dubbed Clovis by archaeologists who crafted the romantic notion that these specialized hunters were the first Americans. This story has been dying slowly over the past thirty or so years and is now defunct. However, no consensus theory has replaced "Clovis First" in spite of a large, vigorous, diverse, and sometimes contentious cadre of scholars in many fields of science looking for the evidence to set the story straight.

This is not a trivial quest, because the Western Hemisphere affords 25 percent of the habitable surface of the earth and was colonized quite late in human history. What people were doing across the entire Northern Hemisphere over the past 50,000 years or so is the focus, along with what the changing terrestrial and marine environments of that expanse of time and space were like.

Relevant data from archaeology, earth sciences, human DNA, and other fields are cascading in at such a startling pace that almost all of the targets are moving almost all of the time. And it's not just the data that are changing; the concepts, techniques, and tools scholars use are improving almost daily. This is an exhilarating time in an exciting pursuit.

Dennis J. Stanford and Bruce A. Bradley draw on ethnography (some of it their own), archaeology (some of it their own), paleoclimatology, oceanography, geology, experimentation (some of it their own), human biology, and more to formulate a hypothesis that accounts for why the Americas seem to have been first peopled during the last glacial period and evidently by way of the harsh artic realm. Since humankind has evolved and thrived in tropical and temperate climes for more than 98 percent of its existence, the circumstances that drove this expansion of range must have been extraordinary.

Extraordinary they were, with great expanses of the earth falling barren under the advance of glaciation, pushing humans into refugia including the continental margins of southwestern Europe and eastern Asia. From these ocean edges, people were drawn toward enormous populations of marine invertebrates, fish, mammals, and birds, particularly in the northerly latitudes. Boats were needed, tailored clothing that was insulated and waterproof was imperative, ingenuity and new knowledge were essential, and new harvesting technologies were required. So with both a push and a pull, the rich maritime environments of the North Pacific and the North Atlantic increasingly became part of the human niche. As people expanded this niche, it brought them to the shores of North America—the immense human journey across the globe had reached a new continent, whence it continued until the Americas were fully colonized. This new story is at the moment just an outline, and filling it in is the ongoing work of many scholars. Their efforts have been productive because they have approached the peopling of the Americas as a process rather than an event.

Among this throng of scholars, Dennis and Bruce have tackled the specific question of the origin of Clovis and here formulate a hypothesis that its technological antecedents reached North America from across the North Atlantic and out of Cantabrian Solutrean roots of circa 18,000 years ago. The technology continued developing in eastern North America, ultimately becoming what we call Clovis. This is a hypothesis worthy of full testing.

Already, in fact, testing is under way. For example, based primarily on nascent accounts of this hypothesis published by Dennis and Bruce in 2004 and 2006 in *World Archaeology,* Kieran Westley and Justin Dix challenged the "Solutrean Atlantic Hypothesis" in the pages of the first issue of the first volume of the *Journal of the North Atlantic* (2008). They presented a comprehensive review of the status of the ice pack margins of the North Atlantic for the entire duration of the Solutrean (16,000–21,000 years ago) and found that throughout most of that time, it is highly unlikely that conditions along the margin were suitable for sustaining even well-outfitted human mariners. They do note, however, that during a brief interval, conditions may well have been favorable. That interval, near the onset of the Heinrich I event, coincides with that part of the La Riera Cave sequence of north-

ern Spain that Dennis and Bruce identify as the probable time of expanding maritime subsistence by Solutreans.

This book brings clear focus to the competing notions that America was peopled out of Siberia or out of Iberia. The authors and I agree that, most likely, it was from both and that the early archaeology of the Americas reflects the first heat in the melting pot of the Western Hemisphere. We hold this view in spite of a prevailing interpretation of DNA evidence favoring a Siberian origin of all Native Americans, a view based on modern and recent DNA. But until confirmed by samples of ancient DNA, this is little more than a hypothesis as regards the earliest peoples in America. Asian styles and technology prevail in the early archaeological record along the western parts of North and South America, while a more European Upper Paleolithic flavor—especially Solutrean—is found along the eastern margins of the hemisphere. It is important to note that the geographic extent of submerged archaeological potential is much greater on the Atlantic side of the Western Hemisphere than it is on the Pacific side. This almost surely translates to greater potential for future ice age discoveries on the submerged Atlantic continental shelf than on that of the Pacific.

But old ideas, pet theories, vested research, and intellectual jealousies don't go away easily. When Dennis and Bruce first let on in the late 1990s that they were thinking about developing the hypothesis that Clovis derived from Upper Paleolithic Solutrean cultural roots in southwestern Europe and that the process included plying the North Atlantic in boats, the collective gasp of the archaeological community was audible. The tone quickly became ugly. After Dennis gave an overview of the idea as the banquet address at "Clovis and Beyond" in Santa Fe in 1999, a senior colleague leaned over to me and said, "I just hate seeing Dennis throw away his career like this." Spirited objections to almost every aspect of this hypothesis have dogged Dennis, Bruce, and any fellow travelers for the ensuing dozen years, but there has also been an increasing willingness among many colleagues and the public to at least give a listen. One major obstacle has been what I call chronoracism, the denigration by our contemporaries of the intellectual and technological capabilities of our *Homo sapiens* ancestors, as for example their forceful resistance to the idea of boats in the Paleolithic. In January 2011 one of my colleagues angrily dismissed my discussion of the Solutrean-to-Clovis hypothesis with "Just show me the boats—where are the boats?"

Good science requires critical examination of evidence and ideas, but it is not served by the unsupported dismissal of either. Thoughtful, well-argued, and evidence-based challenges like that of Westley and Dix are what will advance, modify, or refute the Solutrean hypothesis. Let the march of science begin.

Michael B. Collins
January 27, 2011

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INTRODUCTION

The First Americans?

If at first the idea is not absurd, then there is no hope for it.

ATTRIBUTED TO ALBERT EINSTEIN

Christopher Columbus stumbled across the so-called New World while on a voyage to discover a more direct trade route to India, or so the story goes. Certainly, in his mind, he had found that route, and thus he called the inhabitants "Indians" and the place "the Indies." It wasn't long afterward that this monumental misjudgment of geography was recognized, but the misnomer stuck. But if the New World was not India and its inhabitants were not Indians, who were these people, where did they come from, how did they get here, and when did they arrive?

These questions have fascinated Westerners since Columbus's assumptions were found to be in error, and they are still the major unresolved mysteries of American archaeology. Were these people one of the lost tribes of Israel? Did the universe create them in their own private Eden? As early as 1590, the Spanish Jesuit missionary José de Acosta recognized that Native American physical characteristics were generally similar to those of Asians, so he postulated the existence of a land bridge that once connected the two continents.[1] His logic preceded the proof of the existence of such a land bridge by some 350 years.

Some American Indians like the idea of sharing ancestors with Genghis Khan. Many others oppose the theory that their ancestors came across a land bridge from Asia—or from anywhere else. Their ancestors, they argue, were created in their traditional American homelands; they did not migrate from another continent. Anchored in these spiritual beliefs, these present-day Native Americans are secure in the knowledge that their people were the first in the Americas and have been here forever, or since time imme-

morial. Some of them may wonder about origin stories that contradict these ideas: to get here their ancestors crossed a sea on the back of a huge turtle; when they arrived they had to "fight off the giants" who were already living on the land. But then again, how long is forever? Might not 450 or so generations be as good as forever to mortal beings?

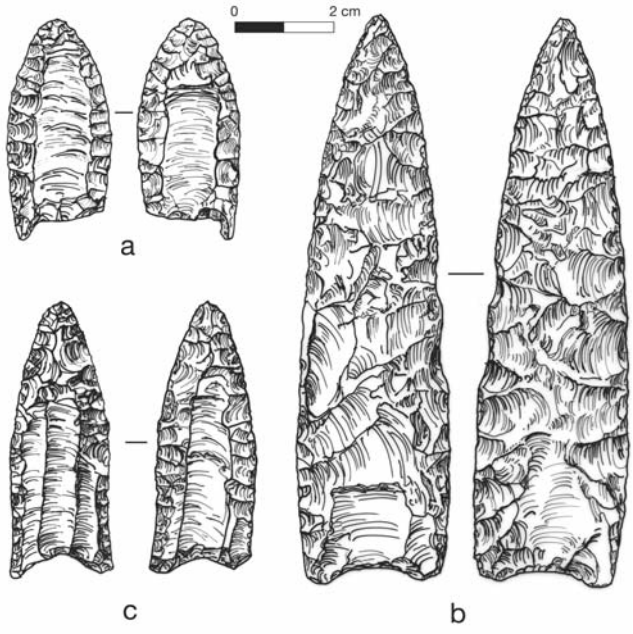
For Western science the story of the Americas, and for that matter of the earth itself, unfolded at a glacier's pace. In the early nineteenth century scientists began to realize the deep time required for the creation of the earth and recognized evidence that massive glaciers once covered much of the world's surface.[2] Charles Darwin's notions of biological evolution followed these discoveries, setting science against fundamental Christian teachings. Scholars made comparative studies of humans around the world and classified human variation into races and societies, which they assumed to be transitional on an evolutionary scale. As part of an effort to classify Native Americans, Aleš Hrdlička of the Smithsonian Institution suggested in 1923 that they had emigrated from Asia at the end of the most recent ice age, or thirteen thousand years ago.[3] He had little evidence to calibrate the timing of this event, but he suggested that the migration took place as recently as 5,000 years earlier and argued vociferously against those who suggested earlier human occupations of the New World.

EARLY HUNTERS OF THE AMERICAN SOUTHWEST

As early as the late eighteenth century evidence was noted relative to these questions, but our present understanding of the "first Americans"—wherever they came from—began to take shape in 1908, when a late summer storm poured an unprecedented amount of water across the basalt mesas and canyons that straddle the high borderland between New Mexico and southern Colorado.[4] The rolling storm created walls of water that cascaded down normally dry streambeds and cut deeply into prehistoric sediments. The turmoil of rain, hail, and crashing lightening scattered range cattle far and wide. After the storm, ranch hands, including George McJunkin, worked to bunch up the cattle and survey the damage. As McJunkin rode down Wild Horse arroyo he noticed large animal bones protruding from newly exposed canyon walls, and even more fossils were scattered downstream. McJunkin's curiosity was piqued because the newly exposed bones were much larger than the cow and buffalo bones he was so familiar with, and because these bones had been buried beneath twenty feet of dirt and clay.

Over the years, McJunkin talked about his discovery, and the legend of the prehistoric monster buffalo spread through the local communities around Folsom, New Mexico. In 1926, when the Colorado Museum of Natural History was looking for ice age remains for new exhibits, a crew went to New Mexico to seek the giant bison and excavate specimens to take back to Denver for display. Although McJunkin had long since passed away, several of his friends knew of the site, and indeed many bones were still visible.

As the museum team dug among the remains, they found a broken flint spear point in the soil encasing a rib cage. Another point fragment unearthed nearby fit onto the bro-



INTRO.1.
Early fluted point finds: (a) Folsom point from the Folsom type site, New Mexico; (b) first Clovis point found with a mammoth at the Dent Site, Colorado; (c) fluted point from the Utukok River, Alaska.

ken point. Moreover, this point had a distinctive feature not seen on the ones they were familiar with: longitudinal flakes had been removed from the base on both faces, producing a grooved appearance (figure Intro.1a). The flaking that produced this form is now called fluting in archaeological parlance.

That fall the news of their finds spread through an unreceptive archaeological community. Scholars were skeptical of an association between the point and the fossil bones because the accepted scientific wisdom was that Native Americans had migrated to the New World thousands of years after the giant bison had become extinct, 10,000 years or more ago. Still, excavations continued at the site for three years, and many more spear points were found. Newly uncovered artifacts were left undisturbed so that visiting scholars could examine the geological context and decide if the weapon tips could have been used to kill the giant bison. By 1928 most researchers considered the Folsom discovery proof that giant bison had been hunted and killed by humans—more than 10,000 years earlier.

Four years later, on the outskirts of Dent, Colorado, another summer gully washer carved a deep ravine along a railroad track embankment.[5] While assessing the damage, Frank Garner, a section foreman for the Union Pacific Railroad, observed that the flood had uncovered a mass of large bones below the track. Very large! These bones dwarfed McJunkin's buffalo bones. These were the remains of mammoths, huge North American pachyderms that went extinct shortly after the end of the last ice age. While examining the bones, Garner found a fluted stone projectile point. (Projectile points are artifacts that were used as the heads of spears, darts, and arrows.) Sensing the importance of the finds,

he notified Father Conrad Bilgery of Denver's Regis College about his discovery. Its location is now known as the Dent Site.

Father Bilgery and several of his students removed the remains of several mammoths. While they were working, they found a long, slender, fluted point of red jasper lying just beneath a mammoth's hipbone. This spear point was similar to the one found by Garner, and both were somewhat larger than, not so precisely flaked as, and with less pronounced flutes than the points from the Folsom bison kill (figure Intro.1b). But because both sets of distinctive weapon tips were fluted, it was thought that the same ethnic group must have made them. It seemed logical that the prehistoric hunters used the smaller Folsom points for killing bison and the larger points for spearing mammoths.

During the same summer that Father Bilgery was excavating the Dent bones, a gravel mining operation began to expose quantities of animal bones and fluted points in uneroded deposits at Blackwater Draw, south of Clovis in eastern New Mexico.[6] Blackwater Draw, now a shallow trough several miles wide, had once been a major river, but it was deprived of water from the upland drainage systems when it was truncated by the headward cutting of the Pecos River during the late Pliocene. Robbed of flowing water, the riverbed filled with wind-blown sand. Then, from time to time, underlying aquifer waters emerged as cool springs onto this parched landscape, known as the Llano Estacada. When the springs had a high enough discharge, they joined the rare rainstorms to form small, ephemeral lakes or ponds along the draw. In seasons when the Llano was dry, the draw and springs were magnets for ice age animals and the people who hunted them. Through alternating wet and dry cycles of the ice age and the subsequent modern environments of the western plains, the ponds, springs, seeps, and interconnecting rivulets were the scenes of life-and-death struggles—now buried in successive geologic layers just waiting for scientists to excavate and interpret.

Skittering back and forth among the jumble of mammoth and bison bone fragments as well as gravel on the shaker screens, projectile points were found at Blackwater Draw—some categorized as Folsom and others looking like those from Dent, suggesting that the same people made all these artifacts. But after the first discoveries in the gravel quarries, controlled stratigraphic excavations disproved that archaeological interpretation. Stratigraphy is the sequence of natural or artificial layers of deposits; in most cases the lowest is oldest, and they become younger toward the surface. These layers represent different depositional events and may tell us how and when they were deposited. Larger, more robust points and mammoth bones were emerging from a deposit situated below the soil that encased the bones of bison killed by Folsom hunters. If there was any doubt, the advent of radiocarbon dating (a method that uses the naturally occurring radioisotope carbon-14 to estimate the age of organic materials) in the 1950s confirmed that Folsom was, indeed, younger than this deeper material. Later paleoecological studies would suggest that the Clovis and Folsom peoples faced radically different environments and that the differences in their weaponry reflected hunting strategies adapted to exploit new climatic

and animal behaviors. The Folsom points, it seems, represented a new weapon technology that was more effective for bison hunting.

The distinctive weapon tips found with mammoth bones at Blackwater Draw were named after the nearby town, and the people who produced these points have since been known as Clovis. Over the years, when these spear points were found along with other characteristic Clovis artifacts in stratified archaeological sites, they were invariably in the deepest, or earliest, cultural strata. Accordingly, they were believed to be the oldest North American artifacts—made and used by the first Americans. Although geologists at the time of discovery estimated the age of these artifacts remarkably accurately, it was not until radiocarbon dating was available that scientists determined that Clovis peoples lived in the American Southwest between 13,500 and 13,000 years ago.[7] This was after the last ice age but during a remarkably cold and dry period of the earth's environment, when many animal genera that had survived the ice age went extinct.

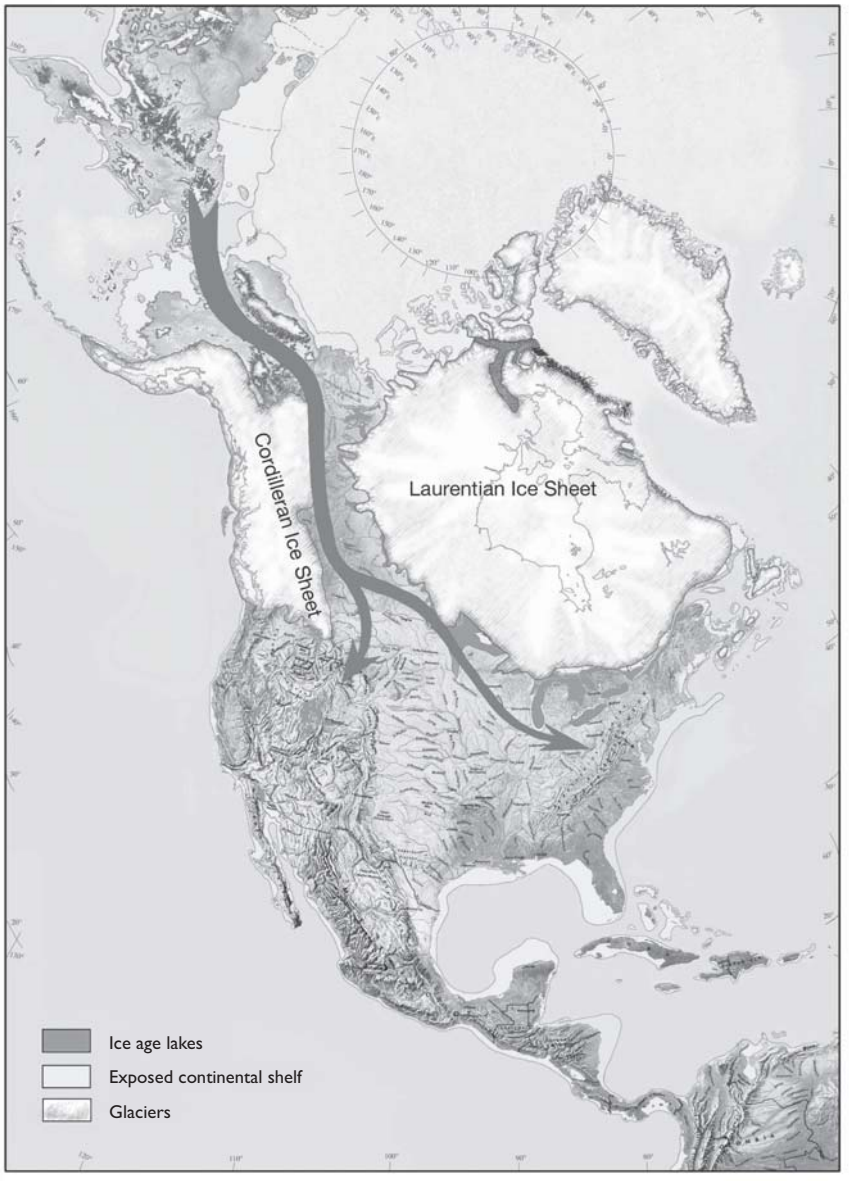
In the decades after the publication of the original Clovis discoveries, Clovis artifacts were documented throughout most of North America and as far south as Venezuela. The standard archaeological interpretation of this wide geographic distribution was that, after arriving in the New World, Clovis people found such an abundance of game animals that they were able to spread rapidly and prosper, their populations filling all of the Americas within several hundred years. But from where, when, and how had they arrived?

MIGRATION FROM ASIA

At about the same time that Clovis artifacts were found at Blackwater Draw, W. A. Johnston of the Geological Survey of Canada pointed out that the formation of massive glaciers during the last ice age had caused the sea level to decline, creating de Acosta's hypothesized "land bridge" connecting Siberia to North America. This bridge, the unglaciated portions of Alaska, and far eastern Siberia are known today as Beringia. Beringia, it seemed, provided a dry land expanse for people—presumably Clovis people—to cross as they migrated from Asia to the Americas.[8]

To complete the logic of this hypothesis, Johnston noted that the glaciers that covered much of North America and Europe began to melt at the end of the last ice age. In particular, he suggested that as the two interconnected glaciers of North America—the Laurentian and the Cordilleran—melted, they left an ice-free corridor that early humans, who had already crossed the land bridge, could use to travel from the Arctic southward into the rest of the Americas. They also released an enormous volume of water back into the oceans, eventually inundating the land bridge (figure Intro.2). This highly logical hypothesis was quickly adopted by the archaeological profession and locked investigators into the nearly unshakable notion that hunters walking over from Asia peopled the Americas.

If there was proof of Johnston's land bridge / ice-free corridor theory, it would be evidence in Alaska and Canada of Clovis-like mammoth hunters leaving Asia for an unknown



INTRO.2.
Hypothetical route of early migration from Asia through Beringia.

new world. The first expedition to test this idea was mounted in 1938 by a group of intrepid graduate students from the University of New Mexico.[9] Supported by a grant from the American Philosophical Society to Wes Bliss, the leader of the expedition, they paddled canoes some two thousand miles down the Mackenzie River to the Beaufort Sea on the Arctic Ocean and explored along rivers over the border into Alaska. Although the Bliss party found several human sites, including caves that contained fossil bones around

Bluefish Lake, Yukon Territory, they did not find conclusive proof of early Clovis migrations through the ice-free corridor.

Thoughts of the ice-free corridor soon took a backseat as new Clovis mammoth kill sites were found in New Mexico, Texas, and Oklahoma, drawing archaeological attention away from the Arctic to lower North America. But in the late 1940s Edward Sable, a geologist working on a mapping expedition for the United States Geological Survey in the Utukok River area in northwestern Alaska, found a fluted, Clovis-like point (figure Intro.1c).[10] As one might imagine, this was major news, and archaeologists were excited about the discovery. Especially noteworthy was the fact that the point was made somewhat differently from Clovis points, and so it might be an earlier or ancestral variety. This find refocused scholarly attention on the North Country and to thoughts about Siberian connections. Within months of Sable's find, Ralph Solecki of the Smithsonian mounted an expedition to the same area in the hopes of finding a site that would produce additional fluted points and resolve the question of Clovis origins.[11] Solecki located more surface finds, but he did not encounter any fluted point sites worthy of excavation.

While Solecki was surveying the North Slope of Alaska, the archaeologists Marie Wormington and Richard Forbis launched a program to assess the ice-free corridor theory from its southern terminus in Alberta.[12] Their hypothesis was that if Clovis peoples had traveled southward through the corridor, their sites would be found in the unglaciated areas of the Alberta plains, since they would have spread not only farther south but also east and west. Along with William T. Mulloy, who later became an expert on the archaeology of Easter Island, Wormington and Forbis conducted the first archaeological survey of Alberta and recorded the presence of prehistoric artifacts found by local collectors. But they found scant evidence of Clovis in private collections—and the farther north they went, the fewer Clovis-like artifacts they found. They did not achieve their goal of proving the peopling of the Americas by Asians, but they did make a major contribution to the knowledge of the northern plains' prehistory.

Since Sable's early find in northern Alaska and Wormington and Forbis's Alberta survey, countless other explorers have sought evidence for the first Americans in the corridor, but the few datable fluted points recovered are no older than the Clovis artifacts they were imagined to precede. Today, after nearly sixty years of research, there is still no archaeological proof that Clovis peoples or anyone before them passed between the glaciers while moving from Asia to the plains of North America. In spite of this lack of evidence, the widely held perception that all Native Americans are closely related to northeast Asians had still convinced many researchers that the mystery of Clovis origins would be uncovered in Siberia. They thought that detailed information about that vast area had been just beyond their grasp, but with the opening up of China for research and the later collapse of the Soviet Union it appeared that this major piece of the puzzle might be forthcoming. Scholars were increasingly allowed to work in Siberia and other areas of Asia in search of evidence to support this model. Dennis was invited, along with the geologist C. Vance Haynes Jr. and the paleontologist Russell Graham, to examine archaeological collections

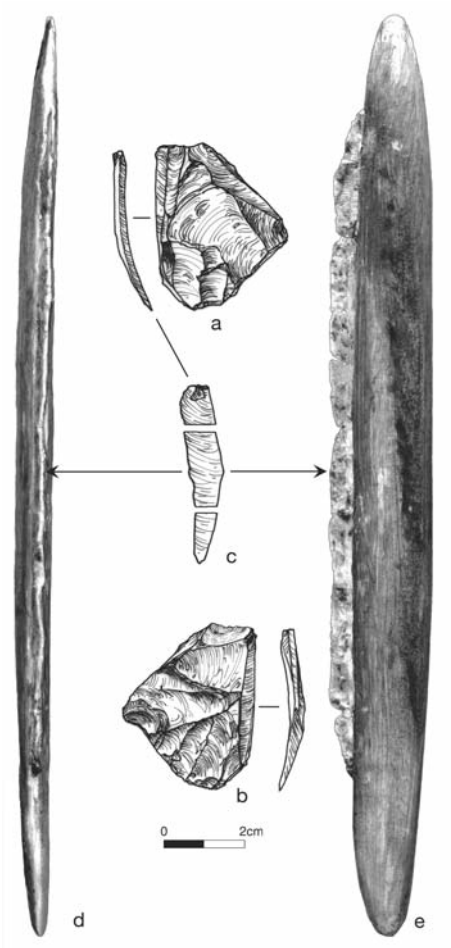
at museums in China and survey for Paleolithic sites along the Heilongjian River on the border between Siberia and northern Manchuria.[13] But they found neither artifacts in any of the museum collections nor archaeological sites that provided evidence of an ancestral Clovis technology.

The late Paleolithic technologies found in Asia are predominately microblades made from prepared wedge-shaped cores (for more information, see chapter 1). In this technology, segments of microblades are inset into grooves in long, narrow, pointed rods of bone, antler, or ivory to form weapon tips and knives (figure Intro.3). This is in sharp contrast to Clovis technology, whose weapon tips are thin, flat bifaces—stones flaked to have one continuous edge and two faces—with concave bases. The few cases of biface technology in Asia are thicker relative to their width and usually pointed at both ends or stemmed (bilaterally indented above the base). Put simply, the Paleolithic northern Asians had a totally different concept of weaponry than Clovis peoples—making them seem unlikely Clovis ancestors.

The refinement of radiocarbon studies of the late Paleolithic sites in far northeastern Asia produced another surprise: all dated sites were either the same age as or younger than Clovis sites. One must travel 1,500 miles or more away from the Bering Strait into Asia to find radiocarbon-dated sites that are much older than approximately 13,000 years old. Again, there seemed to be no evidence of Clovis ancestors in Asia.

To further complicate the deceptively simple Siberia-to-Clovis model, recent research has seriously challenged the presence of an ice-free corridor ecologically capable of supporting human life in time to account for ancestral Clovis migrants.[14] If a model allows the first New World immigrants only their feet for transportation, they could have come through the corridor only after that environment was able to sustain plant and animal life, yet people were well established in southern latitudes before the corridor was biologically viable. For the Siberian model to work, Clovis ancestors must have trekked southward from eastern Beringia during a *previous* warm interglacial period, or at least 28,000 years ago. If that was the case, these Paleolithic people lived in the Americas for nearly 17,000 years without leaving a credible record of their existence here, or in northeastern Asia for that matter. The lack of evidence to support an early entry hypothesis compels us to reject the idea of a much earlier trek.

We are left with a major conundrum. Since there are no archaeological sites in far northeastern Siberia that are older than Clovis, there is no ancestral base there from which Clovis could have developed. The only artifacts found in Beringia that appear to be related to Clovis are clearly younger, so if they are indeed related they were made by Clovis descendants, not Clovis ancestors. Because Clovis technology appears in North America before the Canadian ice-free corridor could support human life, it would have to date to an earlier interglacial period. But there is no clear evidence of such an early occupation of the Americas. A logical conclusion is that Clovis ancestors must have bypassed the great continental glaciers on their way to the New World. Could they have accomplished this



INTRO.3.
Replica of a Siberian compound knife from the Kokorevo Site, with Dyuktai microblade core and microblade: (a) obverse side of microblade core and blade; (b) reverse side of microblade core and microblade; (c) microblade broken into sections, with arrows showing where the uncurved middle section is inset into the slotted bone knife; (d) edge view of knife; (e) side view of knife.

by ocean voyages, either skirting along coastlines and marine glaciers or crossing by boat? Were the Clovis mammoth hunters descendants of mariners?

More than thirty years ago Knut Fladmark hypothesized that maritime peoples exploring along the north Pacific Rim had colonized the Americas.[15] But the idea proved difficult to support, for lack of artifactual evidence. Boats, unlike stone points, are fragile and unlikely to survive thousands of years; even if they did, most places one is likely to find them are now hundreds of feet below sea level. Most archaeologists of Fladmark's time summarily dismissed the thought that Paleolithic peoples might have used oceangoing watercraft. Only recently have scholars taken his idea seriously, in part because of the apparent impossibility of entry into the Americas through the ice-free corridor and in part because of increasing inferential evidence of oceangoing Paleolithic peoples in the southwestern Pacific.[16]

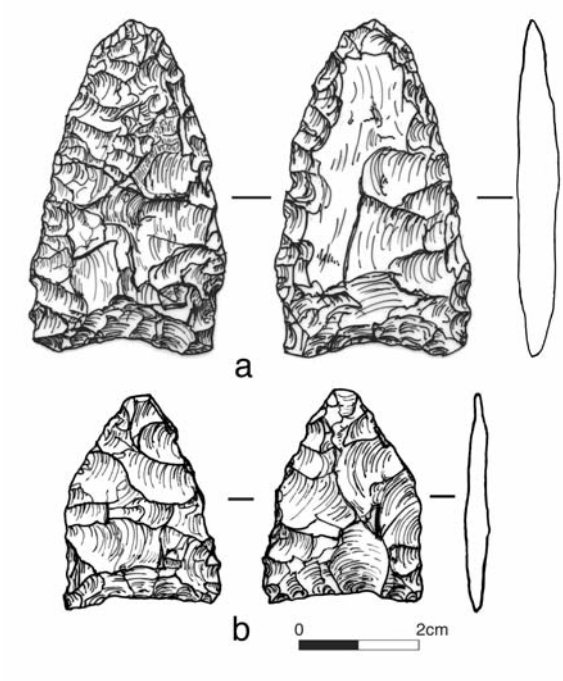
A CONVERGENCE OF POSSIBILITIES

Even though mainstream scholars have accepted the logic of Clovis people being the first inhabitants of the New World, others have long held that the peopling of the Americas was a more complicated issue, pointing to many discoveries of seemingly more ancient human occupations.[17]

During the summer of 1996, Dennis and the Clovis scholar Vance Haynes were touring the eastern United States, visiting various Clovis localities and collections. High on their list was Cactus Hill, southeast of Richmond, Virginia. This stratified site, excavated by Joe and Lynn McAvoy, was the latest contender as a pre-Clovis occupation. The site boasts a sequence of cultures, including late Paleoindian, Clovis, and for the first time undisputed cultural artifacts in an occupation level below Clovis. These artifacts were highly reminiscent of Clovis, with relatively large blades, tools produced from blades and flakes, polyhedral flake cores, and two projectile points (figure Intro.4b). In general, the tools would fit easily into a Clovis assemblage, except for the two weapon tips. These points, although similar to Clovis points in form, were much thinner and had bases that were thinned instead of fluted. Haynes suggested that there were multiple Clovis occupations and that the weapon tips were simply early Clovis points that were broken during use and given a new base, accounting for their thinness and lack of flutes. A radiocarbon date from a probable hearth feature indicated this "early Clovis" assemblage was nearly 16,000 radiocarbon years old.

Soon after his visit to Cactus Hill, Dennis and the Paleoindian expert Pegi Jodry participated in an exhibit in Solutré, France, the site where the European Upper Paleolithic Solutrean culture was first identified and after which it was named. The Solutrean has been dated between circa 18,000 and 25,000 years old. The goal of the exhibit was to compare and showcase Solutrean and Clovis caches—collections of items ranging from special ceremonial offerings to stored equipment or food supplies. Dennis and Pegi became acquainted with the range of French Solutrean artifacts and Solutrean lithic technology and also visited an exhibit on the Solutrean of the Iberian Peninsula that included artifacts from northern Spain. They were impressed by the high degree of flaked-stone and bone technology shared between Solutrean and Clovis artifacts, and Dennis was especially struck by the astonishing similarity of the Spanish Solutrean indented-base projectile points (figure Intro.4a) to those he had seen just weeks earlier at Cactus Hill. Could the ancestors of Clovis have been the Solutrean people of Europe rather than the long-sought Asians?

Several scholars in the past had pointed out the similarities between Clovis and Solutrean technology, but seemingly significant obstacles prevented little more discussion than simply musing over their similarities.[18] Chief among the obstacles were the time gap of 5,000 years between the two cultures and the belief that Paleolithic people did not have boats and could not, therefore, have navigated the stormy ice age Atlantic Ocean. In the face of these problems, most researchers simply dismissed the technological simi-



INTRO.4.
Indented base points: (a) Spanish Solutrean; (b) Cactus Hill. Outlines show sections.

larities as examples of independent invention of equipment used by unrelated people to exploit similar environments.

The Solutrean people carved out a living in southwest Europe during the Last Glacial Maximum (LGM), when most of northwest Europe not covered by glaciers was likely a barren, cold, wind-swept region. It is no coincidence that the majority of Solutrean sites are found near coastal settings or in river valleys, which offered better resources and more amenable environments. It appears that these people lived in the coastal ecological zones for some 5,500 years, and it only makes sense that these fully modern humans learned to exploit the available resources and developed many technological innovations to improve their efficiency at doing so. Could they have had seagoing technologies? Could they have been the ancestors of the people who lived at Cactus Hill?

During Solutrean times the polar front arched about 1,600 miles across the North Atlantic, creating an ice bridge that connected the last ice age coastline of southwest Europe to an island chain off the coast of Canada now known as the Grand Banks. The front would have brought with it all the life-forms that evolved and adapted to living along the ice edge. Solutrean people would have witnessed the many moods of their ice edge environment, growing and blooming, waxing and waning in natural harmony with the weather shifts that punctuated the ice age Paleolithic world. Of course, being out on the ice, they would have learned to harvest the fruits of what the Inuit elders call the "garden" at their doorstep. And while hunting in this icy wonderland, they would have gained an ever-expanding familiarity with and knowledge of this environment that could have car-

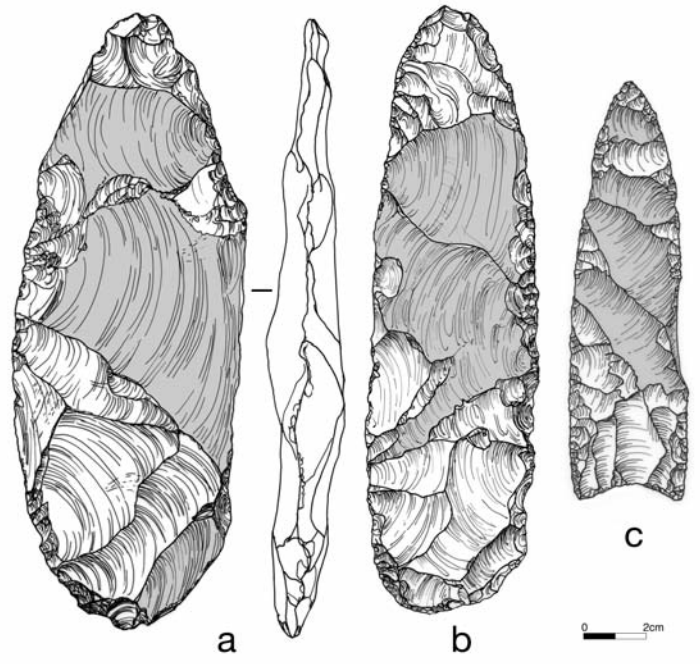
ried them to the Americas. Certainly Solutrean technology is similar to both Clovis and Cactus Hill technologies, and if sites like Cactus Hill represent a version of Clovis several centuries older but still in the Americas, the Solutrean connection seems a much more plausible explanation for Clovis origins than the currently accepted northeast Asian origin theory.

Dennis contacted Bruce to discuss ideas about the possible Iberian connection. Bruce had written his doctoral dissertation on Paleolithic technology and worked at length with the French archaeologist François Bordes, the father of modern European flintknapping—making artifacts from flint stones by applying controlled percussion or pressure to shape the stone into a useful tool. Bruce's skill in flaking chipped stone artifacts and his mastery of most flaking techniques were known around the world, and he had conducted extensive analyses on stone artifact collections from Eurasia, including several Siberian sites.

Bruce had already been impressed with the similarity of Solutrean and Clovis technologies. While working in France in 1970, he had observed that when Solutrean flintknappers made bifaces, they executed flakes that passed from one edge of the artifact and across its face and ended at the opposite edge or sometimes even wrapped around the edge (figure Intro.5). Bordes called this *outrepassé,* or overshot, flaking. Most flintknappers, including Bordes, considered these flakes mistakes made during flintknapping, because such a flake produced by an inexpert knapper usually results in a manufacturing failure. Indeed, some Solutrean bifaces were discarded during manufacture because of an *outrepassé* flake gone bad. The deliberate use of this difficult technique seemed rather unlikely, but the possibility was fascinating.

Years later, when Bruce was working with the archaeologist George Frison at the Agate Basin Site in Wyoming, they tested a locality, known as Sheaman, where flakes were observed eroding from a dry stream bank.[19] At first they found only flakes, many quite large, produced during biface manufacture. These flakes varied in size and form, but many were very flat and had more or less parallel sides, and many exhibited the distinctive terminations of *outrerpassé* flakes. Compared to the flakes Bruce and Frison had found elsewhere, their platforms (intentionally prepared surfaces where the blow was delivered to remove a flake) were unusually wide, straight, and heavily abraded. Bruce was struck by the distinctiveness of the flakes and recalled that even down to the details of how the platforms were prepared, they appeared to represent the same *outrepassé* technique he remembered seeing in the French Solutrean.

The next season's excavations revealed Sheaman to be a Clovis occupation. Bruce recognized that the flakes were probably diagnostic of Clovis and began to note their presence in other assemblages. He has now recorded them in sites across North America, and without exception, when they are present in significant numbers, they have been found to be Clovis. Because the technique is unique to Clovis and Solutrean biface manufacture, even down to the details of how the platforms were prepared, the idea of a historic connection between the two groups makes sense, especially since the many collections the authors have examined from Siberia show no indication that the overshot



INTRO.5.
Clovis overshot flaking: (a) early stage of manufacture; (b) middle stage of manufacture; (c) finished projectile point. Shading indicates overshot flake scars.

technique was systematically used there. And now there seemed to be additional technological characteristics shared by the Cactus Hill and the Spanish Solutrean projectile points, and the Cactus Hill radiocarbon dates were suggesting an overlap with Solutrean times. But was there enough evidence to overcome well-entrenched assumptions and postulate a historical relationship between the Paleolithic Europeans and Clovis people in North America?

Several decades earlier E. F. Greenman had published a major paper hypothesizing that European Paleolithic peoples traveling by boat had lived on and explored the LGM "archipelago" of large ice floes in the North Atlantic until they discovered North America.[20] Most archaeologists of the time rejected Greenman's hypothesis because of his inconclusive and indiscriminate comparisons of North American and European technologies of multiple time periods over vast geographic areas, and no one since that time had taken the issue seriously enough to conduct in-depth comparisons of the Paleolithic technologies of Europe and North America. Moreover, presumptions about genetic relationships based on physical similarities of modern Native Americans and northeast Asians were still strong, and evidence of Paleolithic travelers across the Atlantic still weak.

But the discovery in the Columbia River Basin of the so-called Kennewick Man—with seemingly European features but dated to 9,500 years before the present (BP)—suggested

that human physical traits were not nearly as simple and conclusive as had been assumed.[21] More recently, genetic studies of living peoples around the world have mapped the history of human relationships, and among the results are indications of a distinct human genetic trait shared by some prehistoric and modern Native Americans and some Paleolithic and modern Europeans.[22] At the same time, new tools and methodology have allowed the exploration of submerged maritime Paleolithic sites and the collection of data that is relevant to any hypothesis about early coastal migrations.[23] (Sea-voyaging cultures probably existed worldwide as much as 30,000 years ago, and perhaps as much as 130,000 years ago in the Mediterranean.)[24] Taken together, these new lines of evidence build a picture that makes at least as much sense as the traditional one of Siberians walking to New Mexico before 12,000 B.P. In this newer picture the first people to settle in the New World—or if not the first, then the earliest we have evidence of—exploited the North Atlantic from western Europe. This is the basis of the Solutrean hypothesis.

THE SOLUTREAN HYPOTHESIS

Who were the first Americans? The Solutrean hypothesis, in simple outline form, is that during the Last Glacial Maximum, sometime between 25,000 and 13,000 years ago, members of the Solutrean culture in the southwest coastal regions of Europe were led by subsistence behavior appropriate to their time and place to exploit the ice-edge environment of the polar front across the North Atlantic and colonize North America to become—after several millennia—what we know as the Clovis peoples, who eventually spread far and wide across the Americas. This does not necessarily mean that the Clovis people were the ancestors—or the only ancestors—of contemporary Native Americans, and it does not mean that Paleolithic northeast Asians did not also colonize the Americas. It does mean, in concert with other strands of evidence, that Clovis is part of the rich, complex, and wonderful story of the ebb and flow of people whose descendants are what we call Native Americans.

The past decade, in which we have been researching this theory, has produced increasing amounts of new information, and the pace is quickening. Barely a month goes by when there isn't some new archaeological discovery, new dating of old sites, new evidence of the LGM environment, new DNA interpretation, or other new finding that has the potential to significantly add to and alter our understanding of how people colonized the Americas. For the most part this new evidence has lent support to the theories that Clovis wasn't the first culture in the Americas and that people likely came to the Americas from different places at different times and in different manners. Indeed, it has been difficult to bring a conclusion to this book with all of the new and exciting discoveries.

Humans seek new places to live for at least two reasons: it is hard to make a living where they come from, and somewhere else seems more attractive. This is known as the push-pull concept. Stress encourages people to look for new homes, and perceived plenty is attractive. The hypothesis that we will present is that a combination of limited territory

and a seasonally impoverished terrestrial environment adjacent to a seasonally rich marine environment attracted Solutrean people to incorporate a maritime component into their subsistence patterns. As these people learned to exploit the sea, they followed the southern ice margin of the North Atlantic, eventually making landfall in North America, where at least some remained. During Solutrean times there may have been many accidental and purposeful trips back and forth between southwest Europe and North America. As the ice age waned, the sea ice edge and its associated resources retreated northward, the glaciers melted, and the sea level rose, flooding the continental shelf and increasing the distances across open water. At the same time, the environment of the European mainland improved and the need for a maritime focus lessened. It was no longer necessary, or attractive, to ply the North Atlantic. But by then humans had established a foothold in eastern North America—the earliest foothold on record.

At the core of the Solutrean hypothesis are arguments about historical connections—rather than coincidental similarities—between seemingly different groups of people. Most of the Paleolithic material cultural evidence available to us—whatever the culture being studied—is stone tools, and the distinctive differences and continuities across various groups' flaked stone artifacts are the bases of many of the arguments presented in this book; accordingly, part one begins with a primer that reviews the basics of flaked stone technology, with an emphasis on those issues that are particularly pertinent to our hypothesis. We then present the details of the hypothesis by examining different Paleolithic groups at greater length: chapter 2, the Clovis peoples; chapter 3, the northeast Asian peoples and evidence of a Beringian passage south; chapter 4, American evidence of people preceding Clovis; and chapter 5, the Solutreans of northern coastal Spain and southwestern France.

Part two presents the arguments for the Solutrean hypothesis. Chapter 6 offers intensive comparisons of the flaked stone and bone industries of the Clovis, Beringian, pre-Clovis, and Solutrean cultures. Our quantitative analyses support the qualitative flintknappers' impressions that there is a remarkable, and unmatched, degree of correspondence between the Solutrean and Clovis technologies—remarkable enough to justify pursuing the idea of a historical connection between these peoples. Along with directly comparing specific tool types that occur in Solutrean, pre-Clovis, and Clovis flaked stone assemblages, chapter 7 reviews functional tool types and the nonlithic aspects of these cultures that might support or contradict the idea of historical ties.

Chapter 8 steps into the background of the North Atlantic LGM environments. In recent years numerous interdisciplinary oceanographic studies focusing on sediments from deep-sea cores have provided a wealth of data on ocean ecology and changing marine processes, yet no one has ever seriously considered the ramification of these paleoceanographic data on issues of Paleolithic peoples adapting to the LGM ice-edge environment, let alone to the peopling of the Western Hemisphere. Chapters 9 and 10 apply that climatological and ecological background, along with ethnographic parallels, to an already deep archaeological literature on the Solutrean culture to offer a new look at these

peoples, or a segment of them, whom opportunities of a maritime addition to subsistence and settlement practices could have led west to the New World. In this regard, we review the evidence for Paleolithic maritime voyaging.

Chapter 11 summarizes the evidence, concluding that the Solutrean hypothesis is the most promising explanation offered so far for the origin of Clovis people and the first peopling of the Americas. The Solutrean hypothesis, like any hypothesis, is a skeletal narrative that can incite research in useful directions in a variety of subject areas. There are plenty of gaps in this hypothesis, as there are in the Beringian hypothesis, and thus plenty of opportunities for new research. Ultimately, whether the hypothesis is right or wrong, the many questions it raises and avenues it opens should spur scholars to broaden the scope of research possibilities and produce a more sophisticated story of human history.

PART 1

PALEOLITHIC PEOPLES

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1

FLAKED STONE TECHNOLOGY

A Primer

Investigating Paleolithic cultures, whether in the Old World or the New, is a great challenge because the principal artifacts we have to work with are flaked stone tools and flaking debris. Fortunately, archaeologists have found sites with animal bones, bone and ivory tools, hints of other perishable artifacts, and even rare cases of art, but these are exceptional. Geological and environmental settings can tell us some things, such as the probable conditions in which people lived, but the minuscule representation of the past provided by stone artifacts can give us more details about our distant human heritage. Along with its excellent preservation, flaked stone is important because it directly reflects specific behaviors of individuals within their cultural and environmental contexts, and these behaviors can to some extent be reconstructed. While tool forms are interesting in their own right, we focus on how tools were made; that is, their technology. Many investigated sites from the ancient past represent only specific activities that a group of people performed, and therefore the types of tools found at these places only represent those specific activities. On the other hand, the underlying way that a group makes its tools tends to be reflected in all of its various types of sites. Our technological interpretations are based on decades of studying archaeological remains and decades of flintknapping.

This primer is not intended as a comprehensive discussion of all flaked stone technologies, which would fill multiple volumes. We hope that it will help the reader to understand the basic principles of knapping, including some of the main issues related to the technological comparisons we use to suggest historical linkages. Additionally, since the archaeological literature is full of technological terms whose usage may vary from re-

searcher to researcher, this chapter presents our definitions. We have italicized the key terms to make them easier to refer back to as you read through the book. You may also find them in the extensive index.

PRINCIPLES OF STONE FLAKING

Flaked stone artifacts can be classified into two general categories for the sake of discussion and communication: flakes and cores. A *flake* is the fragment of stone removed from the parent material through the application of force, and a *core* is the parent material after the removal of a flake or flakes. Each flake removal leaves a negative *scar*. The concave area immediately below the core platform is known as a *negative bulb*.

Flakes and cores can be subdivided into many additional categories depending on form, size, patterning, and the like. The stones best suited to flaking technology have fracturing characteristics that most closely resemble those of glass. The mechanics of fracture are complex and have been the subject of numerous studies.[1] For our purposes, it is enough to know that some types of stone break in a predictable way, with knowable mechanical principles, and that the fractures can be controlled to make usable and specific products. Of course, the flaking qualities of stones vary considerably, as do the understanding and skill of the people who select and flake them. Knowledge of this sort does not lie solely in the mystical past. Recent decades have seen a resurgence of practical interest in stone flaking, for both academic and artistic reasons.[2] Hundreds of people in North America make flaked stone artifacts, primarily as a hobby. Expertise in *knapping*—making stone items by flaking—gained through experiment and experiential analogy is now frequently applied to the analysis and interpretation of prehistoric assemblages.[3]

FORCE AND PLATFORMS

To fracture a flakable stone, one must apply force. This can be accomplished in two basic ways: *Percussion flaking* is done either directly, by hitting the stone with another object, or indirectly, by hitting an intermediate object placed between the stone and the striking object.[4] *Pressure flaking* is accomplished by placing a tool against the stone and applying pushing force directly to it to remove a flake. The tools used to apply these forces are made from either hard material, such as other stones *(hammerstones),* or softer material, such as antler, bone, and even dense wood, in which case they are usually called *billets*.

The surface where the force is applied is known as the *platform,* and it produces different results depending on whether it is a smooth flake scar *(plain),* convex with fine ridges *(faceted),* roughened by grinding *(ground),* a natural exterior surface *(cortical),* or any combination of the preceding. Since these variations are under the control of the knapper, platforms are a critical component of flaking technology. Archaeologists have long recognized that flake platforms reflect knapping technology, and almost every analysis of

flakes includes observations about them.[5] This is possible because a portion of the core platform usually detaches with each flake.

Generally speaking, the greater the effort a knapper puts into preparing a platform, the greater the flaking control he or she can achieve. How a platform is placed in relation to the flaking surface is crucial to the formation of the flake. Platform preparation can be relatively simple or very complex, taking up a large amount of time and effort. This is especially true for thinned *bifaces* and some types of *blades* (see below for a description of these forms). Platform details are such an important aspect of particular technologies that, for example, many Clovis flake platforms can be identified as Clovis even when they are not associated with the more readily recognized characteristic projectile points.[6]

FLAKING DECISIONS

The knapper must also consider many details when making specific flaking decisions. Although slight variations in the effect of each action are not usually enough to determine the final outcome of a knapping episode, the knapper's decisions and skill do matter because every piece of stone is different in flakability and form. By understanding flaking processes, it was and is possible for knappers to produce and reproduce desired products within predetermined ranges of variation in size, weight, shape, proportions, edge form, and even flake scar patterns. This is why we see similar tools reappearing together in time and space, forming recognizable *tool kits* (specific sets of tools brought together for a particular task or set of tasks) and *assemblages* (associated groups of artifacts that represent activities over a relatively short time period, also called *techno-complexes*) that differ from those of other people or cultures. Various standard terms used to describe characteristics of flaked stone artifacts are shown in figure 1.1.

A few simple statements can express the expected results of a specific flaking action. Flake thickness depends on how far from the edge the force is applied: the greater the distance, the thicker the flake. The area of contact depends on the platform shape and the size and contour of the striking tool. A sharply pointed hammerstone will have a smaller area of contact than a gently curved antler. Usually, the greater the amount of applied force, the greater the mass of the product. Length is controlled by the angle of the strike in relation to the platform angle. Generally, the closer the angle of force is to 90 degrees, the longer the flake will be, and the more acute the edge angle, the straighter into the core the striking angle must be to create a long flake. The contour of the surface from which flakes are removed determines their form: fracture tends to follow and is guided by the surface ridges and convexities, which are frequently remnants of scars of preceding flaking. For every flake removed (a positive), a negative impression remains (the scar).

What is of paramount importance in understanding flaked stone technology is that every action influences potential future actions and is equally influenced by previous actions. Flaking is a series of causes and effects based on human decisions and actions. The

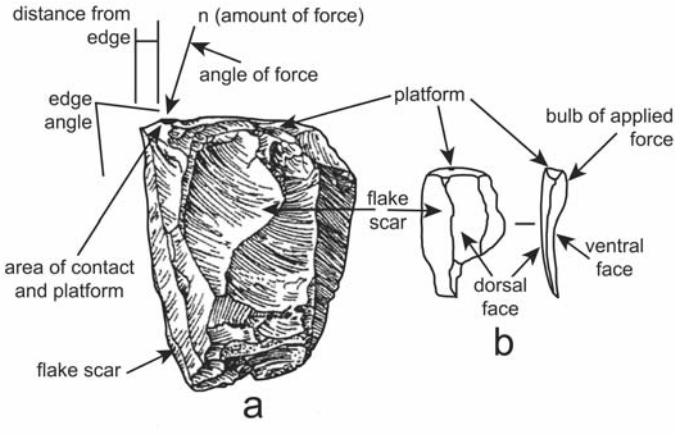


FIGURE 1.1.
Knapping terminology shown (a) on a core; (b) on a flake.

more complex the flaking, the greater the planning and skill in application that are required. By achieving an understanding of these complexities, a Clovis knapper, for example, could produce artifacts with predetermined specifications over and over again. Without this understanding and the skill to apply it, the knapper could not produce Clovis points or other specific forms consistently.

Consistency comes with skill. It is easy to train almost anybody to make a reasonably predictable flake with a bit of basic instruction and a fair amount of practice. However, it is quite another matter for a knapper to attain the ability to make many of the flaked stone artifacts we find in Solutrean, pre-Clovis, and Clovis sites. It is one thing to understand how to do it, but it is quite another to actually produce a complex flaked stone artifact, for example a Clovis point.

PALEOLITHIC TRADITIONS

We recognize four global flaked stone traditions during Upper Paleolithic times (circa 40,000–10,000 years ago): flake, blade, inset blade, and biface. These general technologies can be divided into numerous subsets; for example, we distinguish between thinned and thickened biface traditions (see below for discussions of manufacturing techniques).

FLAKE AND BLADE TECHNOLOGIES

The main products of flake traditions were modified or unmodified flake tools, either handheld or hafted as single pieces (figure 1.2a). While most flakes were used unmodified, many were shaped by the removal of small flakes from their edges *(retouch)*. The mechanics of retouching were the same as those of larger flake production, but retouching

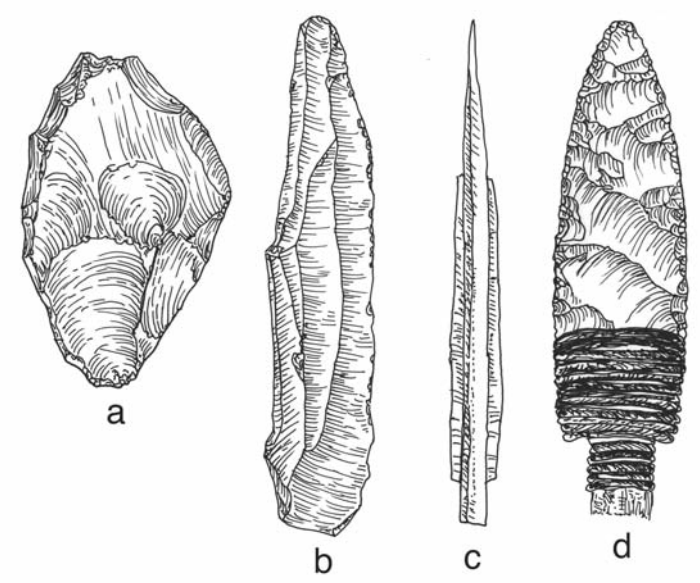


FIGURE 1.2.
Basic tool forms: (a) flake; (b) blade; (c) inset; (d) biface.

was mainly done to modify tool edges rather than to produce usable flakes. Retouch was accomplished with either percussion or pressure. In the simplest definition, *blades* are flakes that are at least twice as long as they are wide (figure 1.2b). They were sometimes produced with no particular preparation of the core, but more often a core was shaped to allow the production of many blades from one piece of stone. We use the term *blade* for these more complexly formed flakes. There were also many different ways blade and flake cores were prepared, which are often diagnostic of a particular techno-complex. Like flake tools, blade tools were made to be used unmodified or modified by retouch, either handheld or hafted singly.

INSET TECHNOLOGY

Inset technologies used multiple small blades or flakes mounted in sequences in grooves in bone, antler, ivory, or wood objects to produce cutting edges (figure 1.2c). Inset technologies may employ blades or flakes of any size but usually used small, specially made stone pieces.

BIFACE TECHNOLOGY

Biface traditions employed single bifacially flaked stone artifacts as handheld or hafted implements (figure 1.2d). These finished tools are generically referred to as bifaces but may also be identified by their inferred uses—for example, as knives, adzes, or projectile points. Many biface technologies also made bifacial flake and blade cores, and caution must be ex-

ercised not to misidentify these as implements. There are cases where a bifacial flaking technique was used to shape a core but no finished bifacial implements were produced within that particular techno-complex. These are not considered biface technologies.

Biface technology developed very early and was the main method of making implements worldwide at the end of the Lower Paleolithic, between 150,000 and 500,000 years ago depending on the region. It was used to make many different products, including knives and hand axes. The latter are bifacial tools that occur in a variety of forms.[7] Although termed axes, they are generally thought to have been multipurpose butchering implements and not used to cut down trees. Non-agricultural North American flaked stone traditions were almost exclusively based on bifacial technologies.[8] In Eurasia biface technology gave way to flake technologies during the Middle Paleolithic, a shift from an emphasis on tools made on whole pieces of stone (core tools) to those made on flakes (flake tools). The early biface technologies were perhaps more complex, but they also demanded a larger amount of stone to produce tools. Some of the Middle Paleolithic flake technologies were also conceptually complex and demanded a significant degree of skill to produce. Once flake technologies were adopted, bifaces only occasionally reappeared until the Neolithic in the Old World. All flaked stone technologies declined as they were replaced by metals, until by the Late Bronze Age they had disappeared or became extremely simple. An exception to this is seen in the eighteenth and nineteenth centuries in Eurasia, where several flaking technologies were developed to supply the demand for gunflints.

Many Stone Age cultures made their tools according to a single basic flaked stone tradition. An example is the Late Upper Paleolithic culture on Zhokhov Island in the Siberian High Arctic, whose only flaked stone products identified to date are inset microblades glued into grooves in bone and ivory points, primarily used to kill polar bears.[9] Other cultures employed more than one technology but had one dominant tradition. Examples include Solutrean and Clovis, which were mainly biface traditions but in some areas had a significant blade technology component.[10] Other examples are the terminal Pleistocene northeastern Siberian cultures that employed an inset blade technology but also made a small number of thick biface tools.[11]

FLAKED STONE MANUFACTURING TECHNIQUES

The distribution of general technologies gives some insight into the past, but we contend it is informative to go beyond this to determine whether similarities and differences in specific technologies may have had direct historical relationships. To this end, we make technological comparisons on a very fine scale. For example, all that was necessary to make small blades was to prepare a platform at an appropriate angle to a flaking surface, from which blades with straight sections could be produced. This sounds simple, but it is amazing how many different ways people developed do it. One approach was to make a thick flake, use its flat ventral surface as the platform, with only simple edge grinding for platform preparation, and remove the first blade from a natural ridge at one corner. In an-

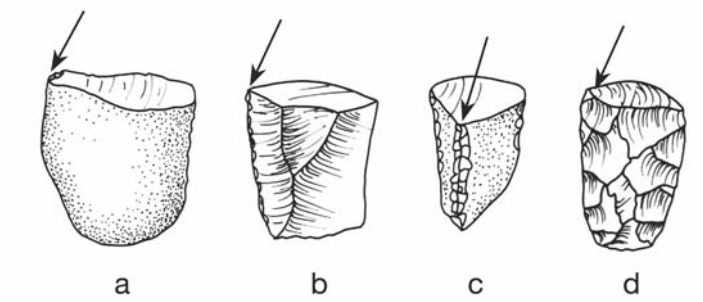


FIGURE 1.3.
Blade core production initiation options: (a) natural ridge; (b–c) simple ridge shaping; (d) all over complex shaping. Arrows indicate the place and angle used to strike the first blade.

other example a small pebble had one end removed to form the platform. A guide ridge was then pressure-flaked and the first blade removed down this ridge. There are almost infinite combinations of techniques expressed in the archaeological record, yet it seems each one was adequate to produce the desired and needed products. In the end, as long as a technology worked, the choice of whether to use it was cultural. We therefore investigate the details of flaking technologies to determine whether such different cultures were related.

BLADE MANUFACTURE

Blade and inset blade technologies developed along the same technological lines and had similar production strategies; the main difference was how the blades were used. Knappers had three main choices for blade production initiation: selection of raw material forms that allowed blade production without preshaping (figure 1.3a); simple preshaping of the material (figure 1.3b–c); and complex preshaping (figure 1.3d). The method chosen seems to have been culturally or traditionally determined.

The shaping options of complex *precores*—blade cores shaped by knappers before detaching the first blade—provide the greatest opportunity to assess whether similarities between traditions were historically connected or the result of independent invention: the more complex the blade technology, the more likely it was to be related to similar technologies.

BIFACE MANUFACTURE

Biface technology may also be relatively simple or extremely complex. Once again, different methods and techniques were developed to achieve the desired products from the available raw materials. Sometimes the materials were less important than the methods: in some archaeological examples, it is possible to observe that although a specific technology did not work well with a particular stone, the knapper persisted without major modification of his or her traditional knapping habits.

It is clear in other cases that the strategy did change during production. This most often involved switching from proportional to thickening or thinning biface flaking (figure 1.4). *Proportional flaking* is accomplished by removing flakes that end just past the longitudinal midline of the biface (figure 1.4a1), proportionally removing as much from the face as from the edge. The resulting biface is lenticular in cross section and has a width-thickness ratio between 3:1 and 4:1 (figure 1.4b). In *thickening,* flaking does not extend through the thickest area (figure 1.4a2), so only the width is reduced. The resultant piece has a width-thickness ratio of less than 3:1. *Thinning* produces flakes that remove proportionally more of the face than the edge (figure 1.4a3), creating bifaces with flat or slightly biconvex cross sections and width-thickness ratios greater than 4:1 (figure 1.4c). As might be imagined, thinning was a risky business, with a probability of failure greatly exceeding that of proportional or thickening flaking.

The best-known and best-described example of biface thickening in North America is Eden point manufacturing technology (figure 1.4d). This point style was clearly intended to be relatively thick, and it took several sequences of carefully controlled pressure flaking to achieve the desired goal.[12] Modern knappers have had a tendency to try to make everything thin because this is one of the greatest challenges, yet Eden points are one of the most difficult technologies to reproduce. The control exercised by Eden knappers was extraordinary, especially considering the fact that the same people were also making some of the thinnest bifaces, known as Cody knives.[13]

Along with proportional flaking, at least three strategies can produce bifaces with high width-thickness ratios: diving, full-face, and overshot flaking. *Diving flaking* drives thinning flakes to near the midline, where they end in either hinge or step fractures (figure 1.4a2), which look the same as thickening because both methods result in flakes meeting at the midline. Hinge and step flakes end abruptly, leaving a relatively deep gouge on the surface, which the removal of a flake from the opposite edge can eliminate, creating a flat and even concave area in the middle. Individual platform preparation and the angle and force of the blow control flake termination. Although this method produces many flakes, they tend to be thin and fragile and of little use except for light cutting. Carefully controlling this process on both faces, however, makes it possible to produce extremely thin bifaces. These tools are very efficient for tasks such as slicing meat, and they can also be used as large but relatively light projectile points. At times they may have been an expression of aesthetics and style: many of the largest flaked pieces used for ritual purposes were thin bifaces. Most archaeological cultures that made very thin bifaces, for example Folsom, used diving flaking.[14] The many examples separated by time and space suggest that this method was independently developed a number of times in different parts of the world.

In *full-face flaking,* flakes travel all the way across the biface, terminating just before the opposite edge (figure 1.4a3). This method is difficult to control and, as the bifaces become thinner, often results in breakage. However, if carefully controlled, this method can produce thin, flat bifaces. *Overshot flaking* is a variation of full-face flaking. In this case flakes travel all the way across the face and remove a portion of the opposite edge (figure 1.4a4).

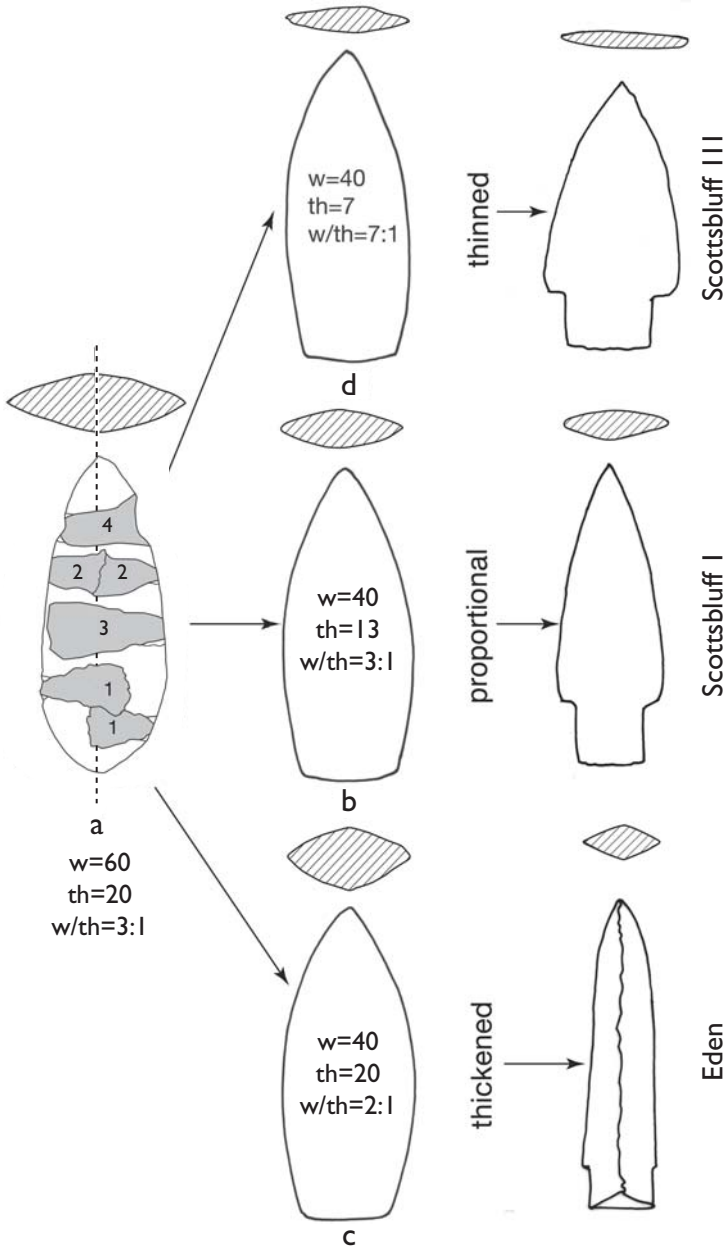


FIGURE 1.4.

Examples of biface flaking options: (a) initial biface; (b) proportional; (c) thickened; (d) thinned. *W* is width, *th* is thickness, and *w/th* is width-to-thickness ratio.

Although this technique may seem counterproductive in that it removes parts of both edges, it eliminates enough mass to significantly thin the biface. It also forms a beveled angle on the edge opposite the platform that frequently requires only minor preparation to be ideal for flaking the other face. Both full-face and overshot flaking require the removal of only a few large flakes from each face to produce a biface that is both thin and uniformly flat. This regularity allows edge and surface finishing, resulting in symmetrical and attractive products, and probably enhances the flakes' functionality. In addition, the flakes are relatively large and straight and are useful as tools themselves. However, these flaking methods are difficult to control, and even small mistakes can result in total failure.

To a modern flintknapper the overshot method is counterintuitive. It seems to waste material, decreases thinning (because parts of both edges are removed), and is extremely difficult to control. Most flintknappers have denied its practicality even in the face of clear archaeological evidence of widespread use. After extensive experimentation, practice, and examination of Clovis and Solutrean assemblages, however, we are completely convinced of its advantages and that it was intentionally used in both traditions. Overshot flaking's complexity and difficulty suggest that it is unlikely to have been independently invented very often. Indeed, we have examined many of the biface traditions around the world and so far have recognized purposeful overshot biface thinning only in Clovis and Solutrean assemblages and on bladelet cores in the Neolithic of Qatar.[15] As this method becomes better known by archaeologists, more overshot technologies may be identified. Nevertheless, it is apparent that this technique was rare.

SPACING AND SEQUENCING

Two other integral parts of knapping are flake sequencing and flake spacing. As stated earlier, each flake removal is enabled and influenced by what came before and affects what is possible after. To create products with specific characteristics, such as blades with two parallel ridges running down the outside surface, the spacing of the flake removals is critical for establishing the proper morphology of the core (for more on blade characteristics, see chapters 2 and 7).

Spacing and sequencing of flake removals are integrally linked, but sequencing may also be done to create a particular surface pattern. Some knapping sequences produce distinct, sometimes culturally diagnostic, flake scar patterns. For example, special flint knives were produced in predynastic Egypt with a unique pressure flaking pattern called S-flaking.[16] This is tricky to accomplish, and we can see no functional advantage to it, so it may have had aesthetic significance.

Those of us over forty years old may remember the cowboy and Indian movies in which a corpse full of arrows is discovered. The hero (often John Wayne) would pull out one of the arrows and after close examination proclaim "Apache." Not only does this make for good movies, but there is also plenty of historical support for the idea that certain artifacts are identifiable with a particular culture, ethnic group, or even individual maker. This was

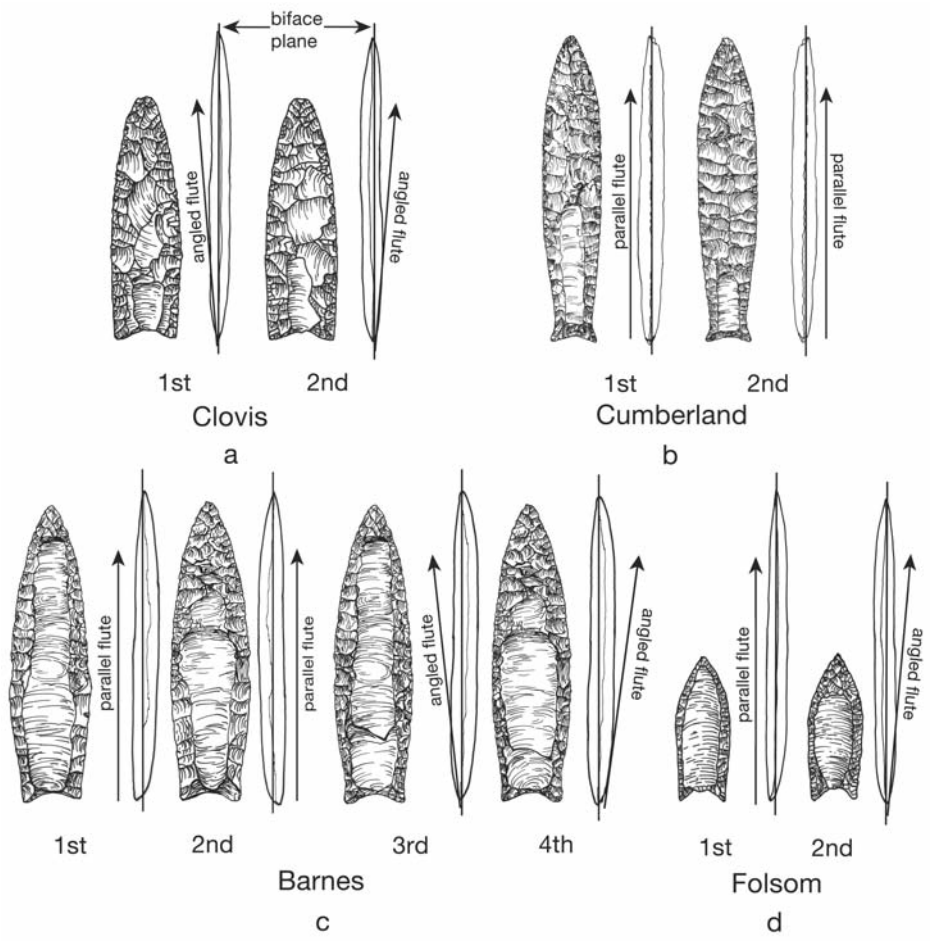


FIGURE 1.5.
Variations in fluting technology: (a) Clovis diagonal/angled fluting; (b) Cumberland parallel fluting; (c) Barnes parallel first fluting of both faces, followed by angled fluting of both faces; (d) Folsom parallel fluting and angled fluting.

certainly true in the past, and it may have been an important aspect of flaked stone style or even technology in some cultures.[17] Highly sophisticated and complex techniques, such as controlled overshot flaking, may be the traits that indicate historical connections.[18]

FLUTING

Longitudinal thinning is another important aspect of early North American technologies. When accomplished during the course of producing *preforms* (unfinished bifaces whose final form is evident) it is called *end thinning,* even when done to a tip rather than a base. When applied so that the finished piece retains the resulting flake scar or scars on its

base, it is called *fluting*. While some bifaces have basal thinning, it is not well enough developed and the flake scars are not long enough for it to be considered fluting. Intentional patterned fluting as part of specific techno-complexes is clearly an American invention. There is some evidence of the development and adoption of this technique in the pre-Clovis materials in eastern North America, but it is totally developed and nearly universally applied in Clovis biface technologies. Clovis is the first assemblage where fluting is well established but by no means the last, and it is even possible to distinguish between several variations in application in post-Clovis fluted point technologies.

We recognize two basic approaches to fluting through the intentional removal of substantial flakes *(channel flakes)* from the bases of points near the end of manufacture. *Diagonal* or *angled fluting* happens when flake removal originates so that the resulting basal edge, on the longitudinal section, is directly in line with the biface plane formed by the rest of the point but the scar is at a diagonal to this plane (figure 1.5a). The second approach is to set up the channel flake platform to project toward the face to be fluted so that when the flake is removed the resulting edge still projects parallel to the biface plane (figure 1.5b). We call this *parallel fluting*.

We can see little advantage of one of these methods over the other, and the approaches were used separately and in combination. For example, in Clovis the flutes on both sides were diagonal, resulting in a sharp basal edge that was in the point's biface plane without additional flaking. A third combination is seen in the point fluting in the Cumberland and Barnes sites of eastern North America. Both faces were fluted with parallel removals, necessitating significant post-fluting flaking to obtain a sharp base in line with the point's biface plane. This was sometimes accomplished with multiple small pressure flakes (figure 1.5b), but another, very distinct option was also used, called *flute under flute:* following the long parallel flute removals, shorter, diagonal flutes were removed from both faces, producing a superimposed channel flake scar on each face (figure 1.5c, 3rd and 4th). Finally, the first flute of a Folsom point was a parallel removal and the second, on the opposite face, a diagonal removal (figure 1.5d).[19] After the first fluting, a substantial adjustment of the basal margin was necessary to set up the diagonal flute, but its removal created a sharp edge in line with the point's biface plane.

The action of flaking stone leaves a record of human thought and behavior not unlike the combining of letters to form words, phrases, and sentences. Archaeologists recover fragments of evidence; now we just need to learn to decipher the languages. This primer presents the background needed to allow a basic understanding of the technological stories we have gathered.

2

CLOVIS

The First American Settlers?

For decades the Clovis culture has been our anchor to understanding the peopling of the New World. It has been a touchstone for archaeologists, a rare "truth" and comfort regarding the unknowable archaeological past. We have recognized who was first in the Americas and whence they came. Even so, the interest in just how they came to be and where they came from has driven Clovis research, which has resulted in questions challenging even our very basic beliefs. What is the evidence that has started to shake the foundations of this long-accepted theory? Could it be that there were people in the Americas before Clovis?

The amount of evidence for Clovis has grown at a relatively fast rate since the first discovery of this archaeological culture. Clovis points have been found throughout most of continental North America, extending from the Atlantic to the Pacific, and from the plains of Alberta, Canada, into northern South America (figure 2.1). The wealth of data provided by the excavation and analysis of Clovis sites is giving us a new understanding of Clovis culture. Although Clovis hunters killed now extinct ice age animals, a conservative view of radiocarbon dates indicates that these people first appeared in the New World some 13,000 years ago, and in less than 200 years they had explored, exploited, and inhabited the two continents of the Americas.[1] By comparison, the historic European residence in the Americas began barely 500 years ago. If the actual tenure of Clovis is only 200 years, they achieved the most rapid terrestrial expansion and extensive colonization in the history of pre-literate people.

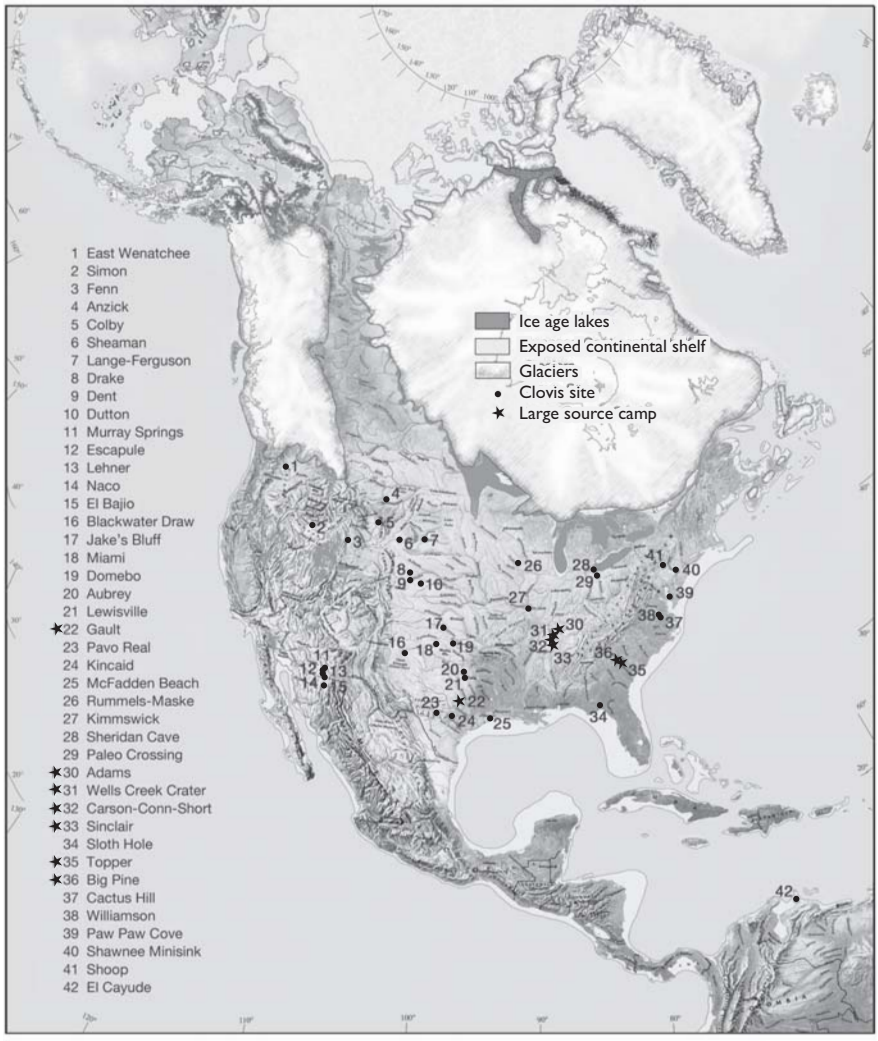


FIGURE 2.1.
Locations of major Clovis sites and extent of glaciation, 12,000 BP.

The Clovis expansion across the Americas coincided with a period of dramatic climatic fluctuations that altered landscapes and their associated resources.[2] Clovis people must have been highly adaptive generalists who could take advantage of a wide variety of resources. Their secular worldview must have centered on the edible and the inedible and how to attain the former. At the end of Clovis times we see users of descendant technologies adapted to every available ecological zone: tundra in the north; boreal forest with deciduous and coniferous woodlands in the northeast; deciduous forest and parklands; mixed hardwood and piney woods in the South; pluvial lakes and rivers in the relatively

arid plains; desert in the southwest; and the tropics of Central America. Moreover, dredging along the Atlantic coast and sports divers on the Atlantic continental shelf have recovered Clovis artifacts from an ocean margin environment. Although Clovis sites and artifacts are rare on the West Coast and in the Great Basin and range country, scattered evidence around pluvial lakes and river courses suggests at least minimal Clovis occupation of these areas.

Fluted projectile points are the most readily identifiable Clovis artifacts, but there are many other items that make up the Clovis inventory. Among these are tools made from blades and flakes struck from specialized cores, plus bifacially flaked knives and adzes. Bi-beveled bone, antler, and ivory rods of unknown use, foreshafts (made to hold projectile points for use with a spear shaft), and projectile points as well as barbed harpoons are also characteristic of Clovis.

SETTLEMENT PATTERNS

The history of Clovis archaeology has had a profound influence on our perception of Clovis culture. The first recognized sites, Blackwater Draw and Dent, were found in semiarid environments; both included mammoth remains. Many other Clovis localities were subsequently discovered in the West. But even though archaeologists have become aware that the climate and landscape of North America were much different at the end of the Pleistocene than they are today, the popular view of Clovis continues to emphasize mammoth hunting in an arid to semiarid region. Yet Clovis artifacts and sites with Clovis-like fluted points have now been found from coast to coast and from Canada to as far south as Venezuela.

In North America, Clovis artifacts are relatively rare in the northeastern and north-central states, and some scholars believe this is because these areas were then recently deglaciated and not settled until late in Clovis times.[3] Clovis sites are most abundant in the Mid-Atlantic and southeastern states and exhibit a wide diversity of activities, whereas diversity decreases to the north and west, where activities are focused on hunting. Western sites are either small campsites or kills that are sometimes associated with small temporary hunting camps. To the east and southeast, by contrast, they include not only kills but also stone processing areas, usually associated with large campsites; large overlook and upland surface sites; and at least one cave/rockshelter. Some of these differences in settlement patterns and site types may be the result of preservation or just plain luck in finding sites, but consistent patterns are emerging. The archaeological evidence suggests that the contrast between the east and the west can be explained by the late ice age prairie-forest border. The abundance of resources in the woodlands allowed at least semi-permanent settlements, while the prairies, plains, and deserts offered large game but little else at the time. Because plant and animal habitats were responding to abrupt and fluctuating climatic changes at the end of the ice age, this margin cannot be identified with

great precision, but the general distribution of different Clovis site types gives a general indication of the location of this change.

Evidence of Clovis dwellings is sparse. Based on lack of evidence to the contrary, it is presumed that Clovis people occupying western sites had highly portable or ephemeral structures, but even hearth features are almost nonexistent. In the east, where larger campsites have been found, one would expect evidence of more substantial housing because of the length of time people could remain in this area. By and large, however, this is not the case, save for the appearance of a pattern of post molds at the Thunderbird Site in Virginia from which Errett Callahan has reconstructed the shadowy outline of a rectangular longhouse.[4] If the evidence from Thunderbird has been interpreted correctly, the people who lived there may have constructed longhouses at sites where they intended to reside for extended periods or those to which they returned on a regular basis.

A discovery at the Gault Site in central Texas provides another example of a possible Clovis dwelling. This is a square cobble pavement with straight sides and distinct corners that measures almost 2 square meters. The sides of the pavement line up with the cardinal points (figure 2.2). As the Texas archaeologist Mike Collins has pointed out to us, the odds against this happening randomly are 90 to 1 (based on a 360 degree circle). The structure is in what would have been a wet valley bottom in fine clay deposits. Surrounding this pavement and resting at the same elevation is a scatter of blades, biface fragments, limestone clasts (possibly artifacts), and bone fragments, leaving no doubt about the pavement's association with an occupation. Collins's recent re-evaluation has questioned the Clovis association based on the lack of diagnostic Clovis artifacts as well as a series of dates indicating that this feature and its associated artifacts may be older than Clovis.[5] Investigations into this issue continue.

There is, of course, a lot of speculation about how the feature was used. A likely possibility is that it was the floor of a small structure, constructed to elevate the occupants above the damp valley soil. Blade segments with evidence of grass and reed cutting were associated with the feature, and Collins imagines that the pavement was laid down and then covered with grass or mats, which in turn may have been covered with hides, making a comfortable platform on which to sleep. It is also possible that reed mats were used as walls to enclose the structure.

Another Clovis cobble pavement was discovered in 1948 in Texas at the Kincaid Rockshelter.[6] This pavement covers a significant portion of the Clovis occupation level (there are more uses of the site in archaeological layers above Clovis), and artifacts and bones from food refuse were found in the cracks between the cobbles. A water seep presently keeps the interior of the shelter wet, and if the soil was damp during the Clovis occupation the cobbles may have been used to provide a dry surface. Why Clovis people selected this wet cave among the many dry caves throughout Texas remains a mystery. Nevertheless, these two sites establish pavement as a method known and used by Clovis people.

In order to understand the intensity and use of the Gault Site, intensive refitting analy-

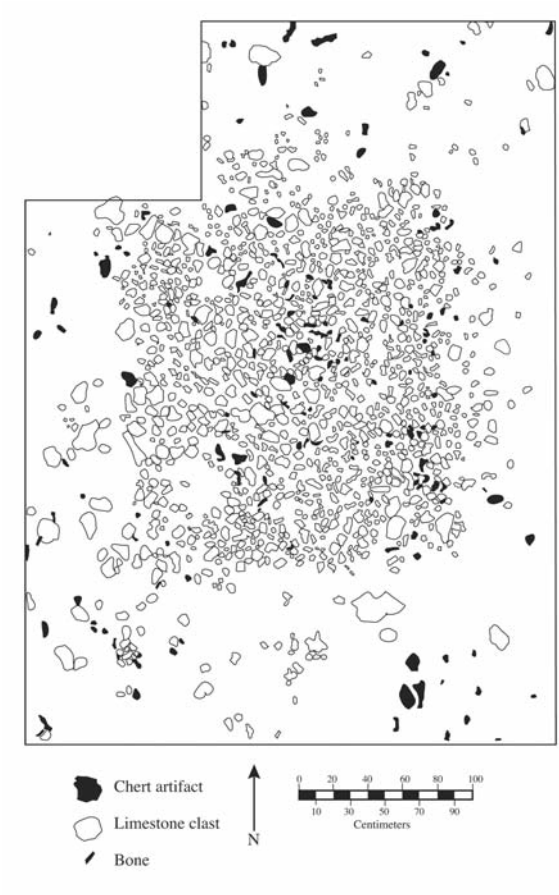


FIGURE 2.2.
Limestone cobble pavement thought to compose the floor of a structure at Gault, Texas. Solid line indicates limit of excavation.

sis has been done there. Flaked stone artifacts were checked to see if knapping sequences could be reconstructed by fitting flakes into flake scars on flakes, cores, and tools. If pieces found near each other fit together, it is likely that they were made and used in that location, and if people used the site only temporarily, especially as a manufacturing locality, one would expect a lot of the remains to be clustered in refittable clusters. On the other hand, if there is a lack of fittable pieces it means there was substantial mixing of artifacts caused by long-term camping activities. The Gault study identified few refits. Since there is little indication in many of the deposits of natural processes moving the artifacts, the paucity of refits probably resulted from human activities that moved individual pieces away from where they were made. Moreover, tools of local chert that were used, worn, refurbished, worn out, and finally discarded are common in the collection and indicate that the Gault occupations were intense and long-term enough to result in this thorough mixing and reuse of artifacts.

Another example of a large Clovis site is the Carson-Conn-Short site on the ice age banks of the Tennessee River, which overflow waters from Kentucky Lake currently seasonally inundate.[7] Although this site has been only preliminarily tested, it appears to be

a major Clovis camping area associated with a chert source. A meter or more of midden (cultural refuse) is spread continuously along the terrace for up to a kilometer. The occupation debris probably accumulated from both long-duration encampments and repeated shorter visits during quarrying activities. Although the brief tests have recognized no evidence of dwellings, the presence of storage pits and possible heat-treating features indicate that this site has great potential for producing evidence of shelters if and when more detailed excavations are conducted.

EVIDENCE OF SETTLEMENT DIRECTION

Almost fifty years ago Ron Mason observed that there were significantly more fluted points reported from the southeast than from the rest of the continent and that there was more variation in fluted point forms and technology in the east than in the west.[8] Following the age-area hypothesis that the greatest number and variations of traits will occur near their center of origin and decrease as they defuse outward, he suggested the southeastern United States and not the West as the homeland of the Clovis complex.

Mason's estimates of the number of fluted points were based on impressions, not on empirical data. But as the years passed, surveys reporting eastern fluted point finds and sites increased at a rapid rate, while western finds remained relatively rare. Twenty years later Louis Brennan, the editor of *Archaeology of Eastern North America (AENA),* in an effort to revive Mason's hypothesis, organized and published a compilation of eastern fluted points.[9] The *AENA* compilation covered the cis-Appalachian East from Quebec to Florida and recorded more than 5,800 points. Although the leading experts on Paleo-Indian archaeology were impressed by the data, they all agreed that the abundance of specimens alone was not proof of the antiquity or ultimate origin of Clovis. Even if the compilation demonstrated that there were more Clovis points recorded from the East, there were likely appropriate explanations—for example, the carrying capacity of the eastern habitats may have been more favorable to population growth, or there may simply have been more artifact collectors and archaeologists working in the East, where decades of agricultural activities likely plowed up more artifacts. Conversely, if there were fewer Clovis points recorded from the West, it was likely that greater erosion there had destroyed many Clovis sites and re-deposited fluted points. A study by the archaeologist Brad Lepper found a positive correlation between the numbers of fluted points reported from Ohio and the amount of acreage under cultivation and associated with contemporary population centers.[10]

Can we evaluate whether or not a greater density of eastern Clovis points reflects better artifact visibility due to erosion and cultivation, plus more intense scrutiny and focused inventories? Certainly there are places where surface exposure is limited in the West, but this is not characteristic of most of the area. Virtually all of the grassland prairies have fallen to the plow, and surface erosion has been so extreme that a large percentage

of the topsoil has been stripped off. We only have to look into the history of the U.S. Soil Conservation Service (now the Natural Resources Conservation Service) to see how widespread this has been and continues to be. Erosion has often reached below late Pleistocene levels, exposing massive tracts of Clovis and earlier deposits, leaving artifacts exposed along with gravels. This process was especially intense during the dust bowl days of the 1930s, and to a lesser degree during the 1950s. These severe droughts exposed an enormous area of what was once prime large-game habitat, especially for now-extinct Pleistocene species.

Some of the most fruitful artifact collecting episodes in North American archaeology took place on the Plains and in the Southwest during the dust bowl. Large private collections of Paleo-Indian (and later) points were assembled from the extensive exposures of late Pleistocene deposits in both regions. Although many Folsom (the fluted point culture that followed Clovis in the High Plains) and later Paleo-Indian sites were documented, Clovis artifacts were rarely found, even though numerous mammoth remains were reported.

Many western collections have been inventoried, and there are regional compilations similar to those in the east. For example, John Cotter and students from Denver University working under the direction of E. B. Renaud traveled throughout eastern Colorado, western Kansas, southwestern Nebraska, and northeastern New Mexico during the 1930s to record Paleo-Indian artifacts found by local collectors.[11] Even though the study was conducted in an area where there was excellent exposure and visibility, as well as extremely active artifact collecting, Clovis points were poorly represented in the collections and accounted for less than 0.04 percent of the total Paleo-Indian point count. It seems reasonable to us to compare these Clovis artifact density results to those in the east, and this pattern has continued to the present, with a large difference in the number of Clovis points and sites found in the western and eastern states.

There is also a far greater diversity of Clovis descendant point forms and technologies in the east. These variations likely reflect local adaptations to varied ecological settings, but links among form, technology, use, and environment have not been established. In the east there are styles such as Debert (figure 2.3a), Cumberland (figure 2.3b), Redstone (figure 2.3c), Barnes (figure 2.3d), and Crowfield (figure 2.3e), to name just a few. Only a single variant, Folsom, is present throughout the western Plains (figure 1.1a), and there is a fluted variety in Alaska (figure 2.3f).[12] Folsom likely developed as part of a bison-hunting specialization, and this point type expands along with the expansion of the grasslands that became the bison range. Consequently, we contend that the greater site density and diversity in point styles in the east support the conclusion that the Clovis tradition has a greater time depth there.

Although most fluted points have been found out of context and on modern ground surfaces in the east, there are major Clovis deposits buried in early terraces of eastern rivers. The densest accumulations of Clovis artifacts have been encountered at Shawnee

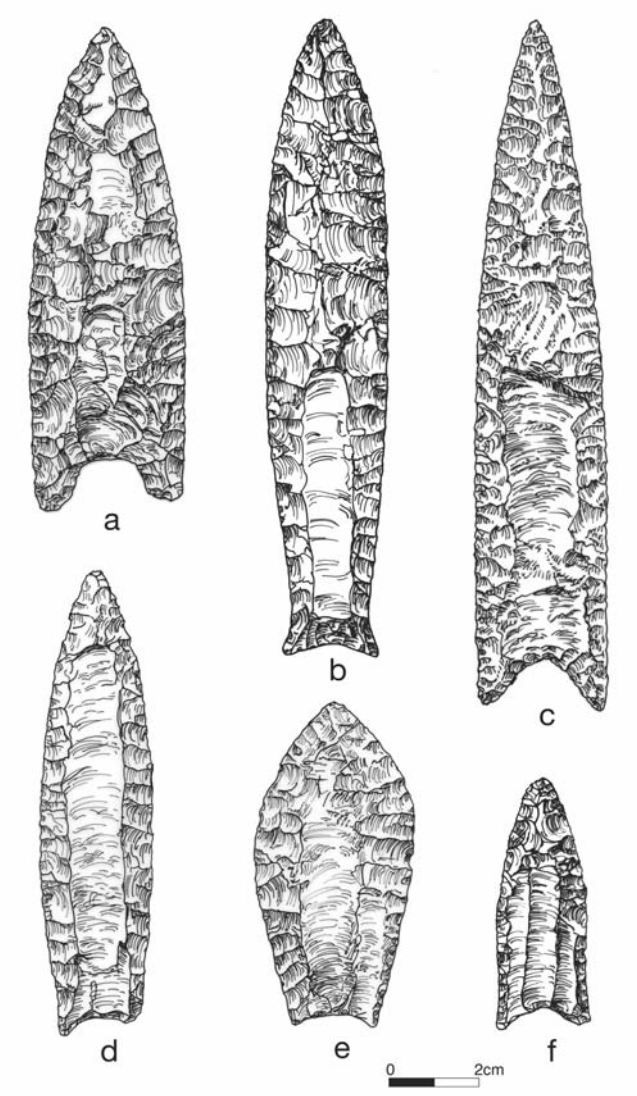


FIGURE 2.3.
Post-Clovis fluted point types: (a) Debert; (b) Cumberland; (c) Redstone; (d) Barnes; (e) Crowfield; (f) Alaska fluted.

Minisink on the Susquehanna River in Pennsylvania, Thunderbird on the Shenandoah River in Virginia, Carson-Conn-Short on the Tennessee River in Tennessee, Williamson in Virginia, Adams in Kentucky, Sinclair Site in Tennessee, and the Pine Tree and Topper Sites on the Savannah River in South Carolina.[13] The Gault Site in central Texas, possibly the largest accumulation of Clovis artifacts yet identified, is situated on a small stream associated with springs. Many of these dense surface accumulations of Clovis artifacts are near or even at chert sources and have artifact assemblages that indicate an extensive range of domestic activities beyond simply obtaining tool stone. No comparable sites are known in the west.

The few western Clovis campsites, such as Murray Springs in Arizona and Shea-

man in Wyoming, are much smaller than the eastern sites, and most are at or near kill sites with associated processing areas, such as Lehner and Murray Springs in Arizona and Lange-Ferguson in South Dakota. The Colby site, in Wyoming, has been interpreted as a meat cache.[14] Even though there are excellent quarry locations with high-quality tool stone used by Clovis flintknappers, associated campsites have not been found. We suggest that the large eastern sites represent a complete cross section of Clovis population that camped on or near stone sources for extended times or for shorter terms but revisited the sites many times, whereas the paucity of evidence found at the western quarry locations, kill/processing sites, and campsites suggests that these localities were for short-term use or specific activities performed by a small subset of the Clovis population.

Large blades are rare in western Clovis assemblages but extremely common at many southeastern sites. The scarcity of blade technology in the west is not related to the availability of high-quality stone. Excellent sources of flaking material (e.g., Alibates dolomite from the panhandle of Texas, quartzite from the Spanish Diggings in Wyoming, and jasper from southeastern Wyoming) are available throughout the west and were used by Clovis people for projectile points but seldom for blades. The differential distribution of large blade technology may be related to chronology; that is, blades are also absent from late Clovis assemblages such as Thunderbird in the east. Or they may have been used in specific tasks that might have been gender related. Use-wear analyses of blade tools suggest that they were used for hide working and for the construction of matting, both frequently female tasks in historically documented foraging societies. The dearth of blades may signify that hide procurement and processing and the establishment of more durable living structures were not part of western activities. Along with the minimal occupation debris left at campsites, the lack of blades may point to small, mobile exploration parties rather than larger bands. However, it can be argued that blades occur in the same proportions to projectile points in the west as in the east, since Clovis artifacts are relatively rare in the west. Unfortunately, it is difficult to evaluate the circumstances of the occurrence of blades as few reports include relevant chronological or use-wear data.

Even when the various indications of greater Clovis population in the east are accepted, they are usually still interpreted as evidence of a west-to-east settlement pattern. For example, David Anderson and Jack Gillam produced geographic distribution maps based on a systematic database compiled from fluted point reports in official government files.[15] When plotted at the county level across the continental United States, the density of fluted points is clearly greater in the east (figure 2.4). On the basis of this information Anderson and Gillam proposed several colonization models—all based on the assumption that Clovis arrived in the west and expanded to the east. Accordingly, they explain the high density of eastern points by supposing that the first migrants were few in number and that their population grew as their territories expanded southeastward along major rivers such as the Missouri and Mississippi to eventually end up on the eastern seaboard. The

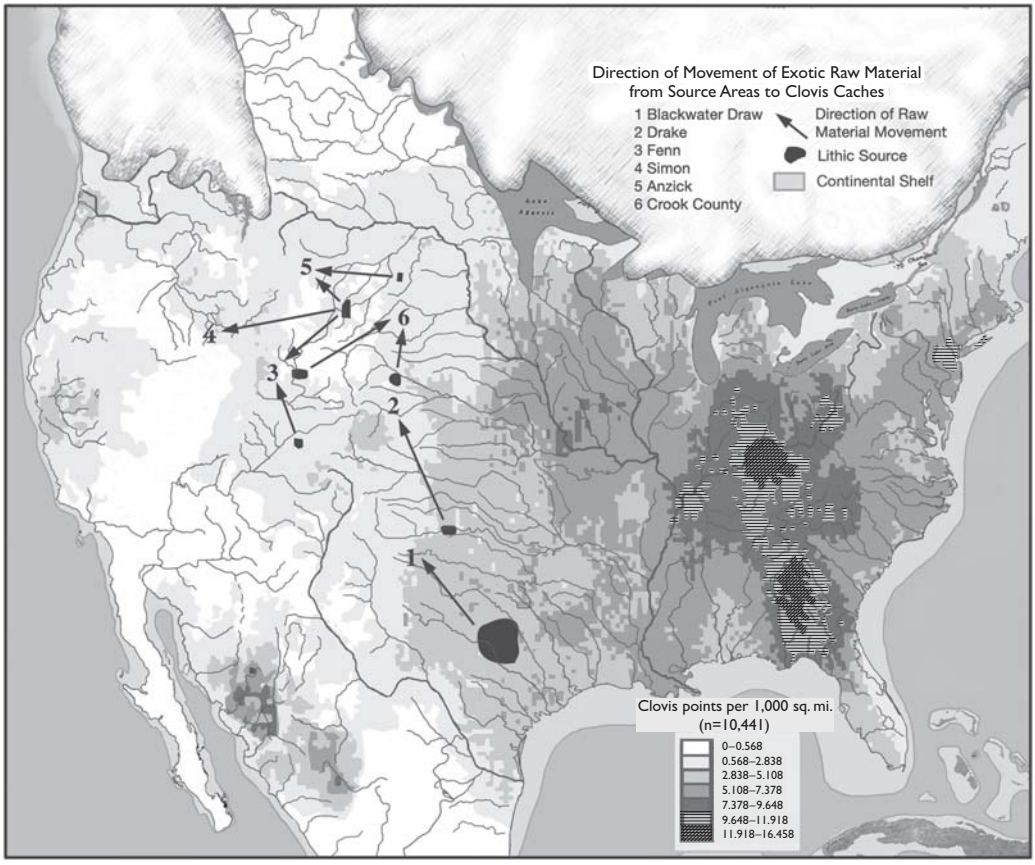


FIGURE 2.4.
Density of Clovis finds and raw material movement, 13,000 BP. (Based on Anderson and Gillam 2000.)

eastern environment was much more productive than the western, resulting in a large human population concentrated in several geographic centers.

But there are lines of evidence that seem to effectively challenge the eastward-expansion-of-Clovis hypothesis. One argument involves the nature of caching behavior. Caches are places where large numbers of artifacts or small groups of projectile points were buried. Clovis people left three varieties of caches: groups of blades, groups of projectile points, and mixes of projectile points, biface preforms, and tools.[16] Currently, the best-known Clovis caches are west of the Mississippi River, but a growing number are being identified farther east. The caches may have been made for various purposes, ranging from logistical caching of tools for later retrieval to ritual offerings never intended to be reclaimed. In a thought-provoking paper, the Southern Methodist University archaeologist David Meltzer hypothesized that when Clovis people colonized

a new, uninhabited landscape, they anticipated the possibility of difficulty in finding raw materials for tool replacement.[17] To prepare for such an eventuality, they created insurance caches of artifacts across the landscape as they moved away from known resources. Thus, caches served as resupply depots; if explorers didn't find stone sources in the new territory, they could resupply from a stash strategically near the margins of known territory. This strategy would be essential for exploring and learning new lands, making it possible to venture farther and more widely across otherwise unknown terrain. Presumably, if new stone sources were found the explorers would not need to return to a cache, which may account for the number of these features in the archaeological record.

We agree that the caching behavior pattern has great practical benefits during exploration ventures, and we contend that the source areas for the raw materials found in a cache clearly indicate the general areas and directions from which explorers came. To test the directionality of Clovis exploration, we assembled information on the long-distance transport to the western caches of stone identifiable to specific sources. In six out of seven caches (the seventh contained only local material), all of the stone obtained from sources more than 150 kilometers away originated from sources south or east of the cache location. Only the Green River chert in the Crook County, Wyoming, cache traveled from west to east, but it also went north. The single Clovis point found in this cache probably originated in the Spanish Diggings area to the south. Although this pattern is not conclusive, it does not support the notion that Clovis folks were exploring from the west or northwest; instead, it supports just the opposite direction of travel.[18]

If Clovis culture originated in the east and spread westward, the eastern radiocarbon dates should be earlier than the western, and there are some indications that this is the case. Conversely, if Clovis originated in the northwest and moved toward the southeast, the earliest dates should be in the northwest. So far, they are not (figure 2.5).[19] The oldest accepted radiocarbon assays for Clovis are 11,540±100 and 11,590±90 RCYBP (radiocarbon years before the present; see the introduction for information about this dating method), both from the Sloth Hole Site, Florida, a long way southeast from any northwestern entry point imagined in a Beringian origin hypothesis. The youngest dates associated with "Clovis-like" fluted points are 10,400 RCYBP, from Charlie Lake Cave in British Columbia, Canada, and circa 10,300 RCYBP from northwest Alaska.[20]

If correct, these radiocarbon dates indicate at least a 500-year period during which eastern Clovis people honed their fluted point technology before expanding westward to the prairie margins. This extended period would account for the abundance and diversity of artifacts found in the east, along with large occupation sites with deep refuse middens. The younger western radiocarbon dates, minimal usage of the western landscape and stone resources, and presence of insurance caches of raw materials originating from distant southeastern sources suggest that Clovis bands were expanding their territories out of the east and southeast.

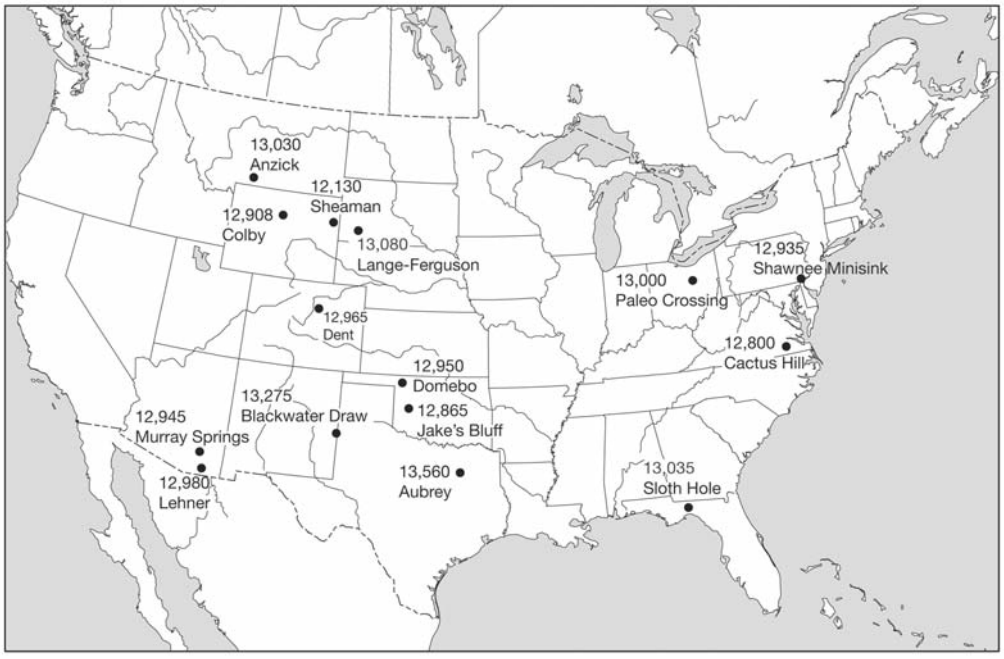


FIGURE 2.5.
Clovis sites with calibrated radiocarbon dates.

It is our opinion that the rapid expansion of Clovis peoples into the Southwest and the Plains would have taken place at the onset of the Younger Dryas, a period of rapid climatic change when the weather turned cold and dry. It is clear that water tables were dropping in the western Plains and Southwest, as evidenced by hand-excavated wells at Blackwater Draw and Murray Springs, and this situation may have been more widespread than we currently understand.[21] Plummeting temperatures and decreased moisture would have had a major impact on the climate and ecology, causing a significant reduction in plant and animal resources. If eastern Clovis relied on coastal estuarian resources as a primary subsistence element, a drop in sea surface temperature would have caused food shortages. Consequently there may not have been sufficient resources to support a large southeastern human population. Moreover, during this cold, dry period many of the larger animals, such as the mammoth, mastodon, sloth, camel, and horse, became extinct in North America.

Westward expansions may have occurred in different ways, including exploration along major rivers and the Gulf Coast. The river orientation of Clovis people continues in the prairies, with major concentrations of artifacts along rivers and especially at the junctions of major rivers and streams. For instance, the majority of Clovis points from Iowa have been found in counties along the Mississippi, Missouri, Iowa, and Des Moines rivers, and they are especially concentrated in the region adjacent to the confluences of these

rivers.[22] Moreover, the majority of recorded Iowa projectile points are made of raw materials from locations to either the east or the southeast.

Expansion onto the prairies and plains and ultimately to the West Coast took place near the end of Clovis times, and it appears that the Clovis use of the west was by small bands of explorers rather than large groups of colonizing people. This exploration was wide ranging, covering virtually all geographic areas and ecological zones, but it did not include long-term settlement.

That Clovis people met other peoples during these explorations is strongly hinted by the contents of the Fenn Cache in Utah.[23] In this cache, along with the usual horde of typical Clovis bifaces and projectile points, was an item previously unknown with Clovis artifacts, a crescent bifacial artifact. Since this artifact form is thought to have its origin among Great Basin non-Clovis people, its presence in the Fenn Cache suggests that descendants of people who colonized the New World by expanding along the north rim of the Pacific Ocean encountered and exchanged technological ideas with Clovis peoples.[24]

Once the large herbivores such as the mammoth, camel, and horse became extinct, the bison was left without effective competition for expanding grasslands, and herds flourished. As a reaction to this resource windfall, people in the Plains adapted to the new environmental conditions and focused their economy on bison. They modified their hunting equipment into more specialized and effective weapons tipped by the fully fluted projectile points we now call Folsom. The advent of Folsom technology coincides with the appearance of the first western large habitation sites, such as Adair-Steadman in western Texas, Lindenmeier in northern Colorado, and Hanson in northern Wyoming.[25] These sites are comparable in size and contain tool kits that represent diverse activities such as we see in the large eastern Clovis sites.

SUBSISTENCE

Animal bones and other perishable specimens used to reconstruct subsistence activities are rare in their sites, but a few remarkable exceptions provide us a glimpse of the types of food Clovis people consumed. The primary animal remains found in western sites come from mammoths, and since these spectacular sites have been in the literature longer than those where a much more mundane diet is evident, the concept that Clovis people were mammoth specialists has become ingrained. The evidence even in the west is, however, beginning to change this image. At the Murray Springs Site in Arizona a small bison kill complemented a mammoth kill.[26] A campsite nearby yielded broken artifacts from both the mammoth and the bison kills, leaving little doubt that the inhabitants were the perpetrators of both events. Further, there is a bison kill in western Oklahoma associated with Clovis points.[27]

Camel bones and possible tools made of camel bone have been found at several Clovis sites, but there is no direct evidence that the Clovis people killed these beasts.[28] At a

Hell Gap Paleo-Indian bison kill on the outskirts of Casper, Wyoming, archaeologists found the remains of a camel that met his end several millennia before the bison. A Clovis point found in the vicinity lead to speculation that the hunter who lost the projectile point killed the camel.[29]

Mastodon and mammoth remains along with Clovis artifacts made from ivory and horse bones have been found in submerged Florida sites, fitting the western stereotype of the mighty big-game hunter. However, western-style mammoth kill sites are rare in the east, where most complete Clovis projectile points are isolated specimens from upland settings. This suggests a procurement strategy in which an individual hunter or small group stalked small herds or even single animals, such as deer, that would have been common in the eastern woodlands. Burned fragments of caribou bone have been found in hearth features in the northeast, suggesting that late Clovis people hunted a variety of tundra and steppe animals.

At the Shawnee Minisink Site in Pennsylvania, fish bones and hawthorn seeds were found in what appears to be a summer camp, pitched between a stone quarry and the Delaware River.[30] At the Aubrey Site on the banks of the Trinity River near Dallas, Texas, evidence was found of mammoth, bison, ground sloth, and even small mammal and reptile procurement.[31] Farther up the Trinity at the Lewisville Site, hearths with burned bone suggest a summer encampment where the main foods included small mammals, amphibians, reptiles and reptile eggs, and baked mud dauber larvae.[32] And at the Kincaid Rockshelter in southern Texas, the Clovis menu included alligators, turtles, badgers, raccoons, and mice.[33] Thus, it appears that Clovis peoples were capable of exploiting almost any environment they encountered and adapted readily to local fare. Still, it is noteworthy and unexplained why mammoth remains, with only a slight hint of smaller game resources, dominate the High Plains and western sites.

FLAKED STONE TECHNOLOGY

Clovis subsistence was accomplished in large part through the use of flaked stone tools. Although there are minor variations in their overall tool forms, there are nonetheless enough similarities that one can easily distinguish Clovis and descendant fluted point assemblages from all other archaeological cultures and time periods. Clovis sites exhibit very specific material culture and behaviors (table 2.1). By and large, regional differences developed in Clovis and post-Clovis tools through time, but they can all be linked through a list of related production and artifact traits that we posit have common origins.

Much ink has been spilled over the significance of fluted point variation, but from our point of view the artifact forms recovered in most archaeological excavations usually represent the end point of a tool's use, making stylistic comparisons difficult. After manufacture, artifacts were used, broken, repaired, broken, repaired again, and eventually discarded, only to be found millennia later by archaeologists, who try to make sense of their

TABLE 2.1 Clovis Production and Artifact Traits

Behavior	Products	Distinctive By-Products
Material selection	Exotic stones	N/a
Blade production	Large blades, small blades, blade tools	Conical cores, wedge-shaped cores, core tablets
Flake production	Large flakes, flake tools, flake blanks for bifaces	Discoidal cores, large thin biface cores, irregular cores
Biface production	Large flakes, knives, adzes, choppers, projectile points	Overshot flakes, channel flakes, platform preparation
Bone/ivory/antler tool production	Sagaie, beveled rods, shaft wrenches, atlatl hooks, perforated teeth	Cutoffs, splinters
Decoration	Incised stones, decorated bone/ivory tools	Use wear on tools
Caching	Bifaces, points, other tools, flake blanks	Ocher stains

discoveries. Occasionally we get a glimpse of what Clovis points originally looked like, in the form of caches and hunting losses. However, given the state of the majority of artifacts we find, what is the meaning of variation? Are there common denominators we can use as rules of classification? We know of many definitions of what a classic Clovis point looks like. If the "type Clovis point" from Blackwater Draw defines the type (figure 2.6n), how does it compare to the rest of the Clovis points from the same site? There is in fact a wide range of variation in Clovis point forms from Blackwater Draw (figure 2.6a–h and k–n). A typologist would have trouble identifying several of these as Clovis, yet their context indicates that they are all part of the same flaked stone assemblage. Differences like these are evident even in kill sites, but variation is even more apparent in large habitation sites such as Gault in central Texas.[34]

Clovis people used a unique technology to produce a distinctive style of projectile point that can be distinguished even from other fluted points that are their regional successors. Even so, there is not a single form of Clovis point, and we see variations through time and space. Moreover, repairing broken points could change their length-to-width and base-to-blade proportions and affect the shape of the base or the area designed to accommodate hafting. In some cases, a point was modified and used as a knife or other type of tool. All Clovis points were probably not intended for identical uses, because Clovis hunters stalked and killed a variety of game ranging from mammoths to mice. Additional variation was introduced by differences in raw material and in the skill and experience of the knapper. Even the amount of time a flintknapper had to devote to the production of a re-

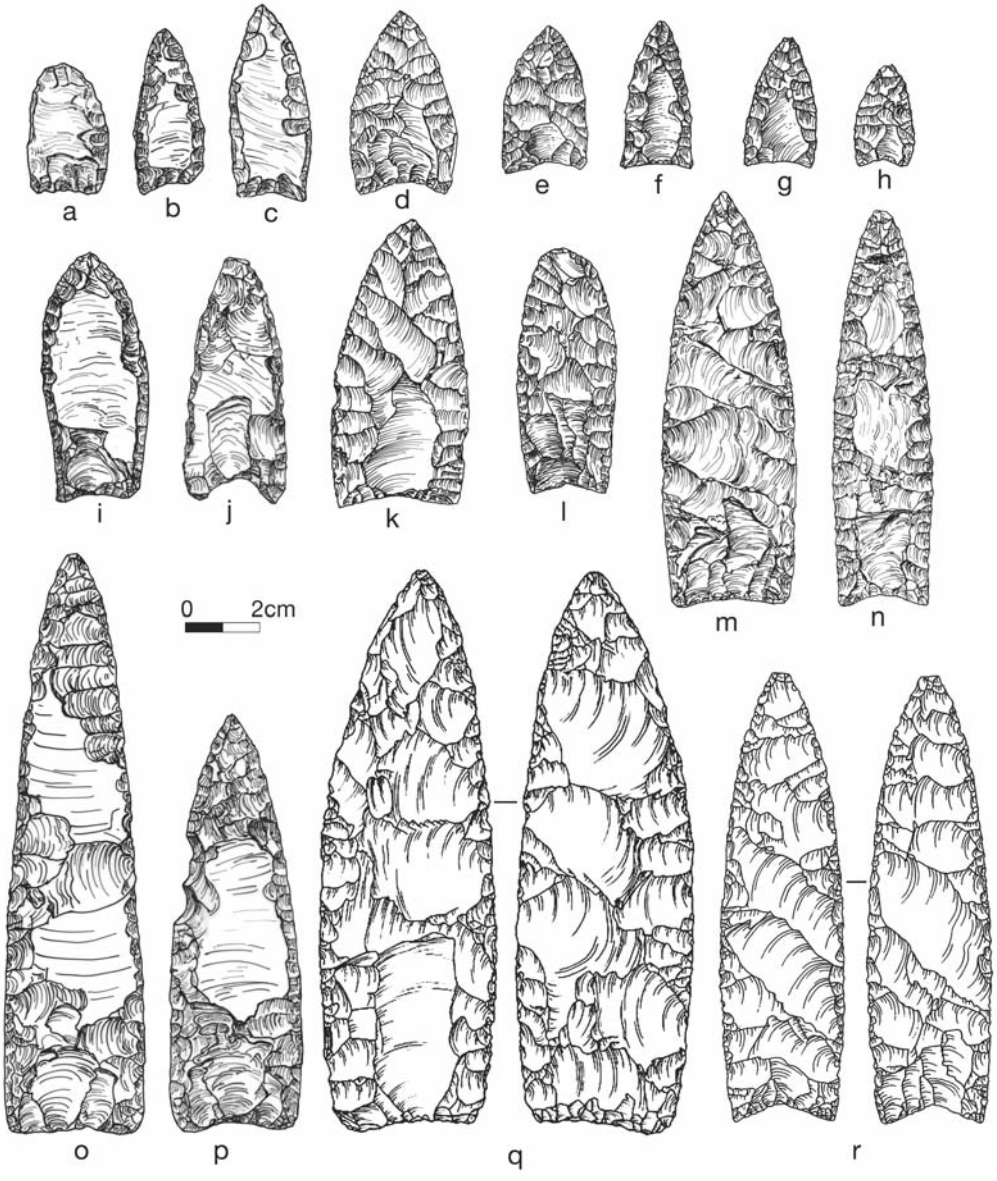


FIGURE 2.6.

Clovis point variations: (a–c) reworked and partially bifacially flaked from Blackwater Draw, New Mexico; (d–h) reworked from Blackwater Draw; (i–j) partially bifacially flaked from Queen Anne's County (i) and Kent County (j), Maryland; (k–l) reworked and (m–n) original forms from Blackwater Draw; (o–p) partially bifacially worked originals from the Anzick Site, Montana (o), and the Drake Site, Colorado (p); (q) middle phase biface end-thinned on one face only from the Fenn Cache, Idaho; (r) finished and unfluted Clovis point from the Fenn Cache.

placement spear tip—for example, in emergency situations—could have resulted in variation from the norm.

Clovis projectile points were manufactured with a generalized bifacial flaking technology; that is, flakes were removed from both faces of the specimen during its manufacture (chapter 1 for more about bifaces). This is in direct contrast to unifacial technology, in which flakes are removed from one face only. While there are examples of Clovis preforms and points that were fluted on only one face (figure 2.6q) and some points that exhibit no fluting (figure 2.6r), there are quite a few that were flaked primarily on one face (figure 2.6a–c, i–j, and o–p) with the other only partly modified, occasionally by the removal of characteristic flute flakes from the base (figure 2.6i–j).[35] Edge grinding normally extended from the base to the maximum width of Clovis projectile points, which is usually about a third of the length from the indented base. The indented bases were edge-ground as well, and some have slightly flared ears. The point edges are usually slightly convex and taper to a sharp but not elongated tip. For the most part, Clovis points are relatively thin and are thickest at about the location of the greatest width.

What continues to interest us is not how much variation there is, even with the aforementioned circumstances, but how distinctive Clovis points, tool types, and manufacturing technology are across much of the Western Hemisphere over a span of several hundred years.

The evidence from a variety of sites, including stone procurement areas, campsites, caches, and especially workshops, makes it clear that Clovis biface production was a highly developed technology. It is also evident that although Clovis shares many traits with other biface technologies, it has certain unique techniques and combinations of techniques. Clovis people used many of the by-products of their bifacial technology for tools, and indeed the technology was probably perfected in part to produce these other items. Particularly important were the large, flat biface thinning flakes, especially useful as butchering and skinning tools.

Another distinctive aspect of the Clovis flaked stone industry was the selection of exotic materials, especially in the west. Clovis knappers went far out of their way to obtain the highest-quality and most colorful stone and acquired flake stocks and artifacts from vast distances, through exchange, direct procurement, or both. Clovis knappers had the pick of the litter at stone outcrops because they were often the first people to explore many of the geological areas they encountered. One stone type they sought out was quartz crystal (see Bradley et al. 2010, plate 1). Although high-quality optical quartz flakes reasonably well, its brittleness makes it a challenge to work. Why they chose this stone when many other, more suitable types were readily available is not clear. Perhaps it was because of its special optical or perceived spiritual characteristics. Certainly crystals have held special significance for people worldwide and throughout time. Although many non-Clovis knappers used rare stones, the degree to which Clovis people went to obtain colorful raw material is unparalleled in the prehistory of North America.

When large pieces of stone were available, the preference was to make big bifacial flake

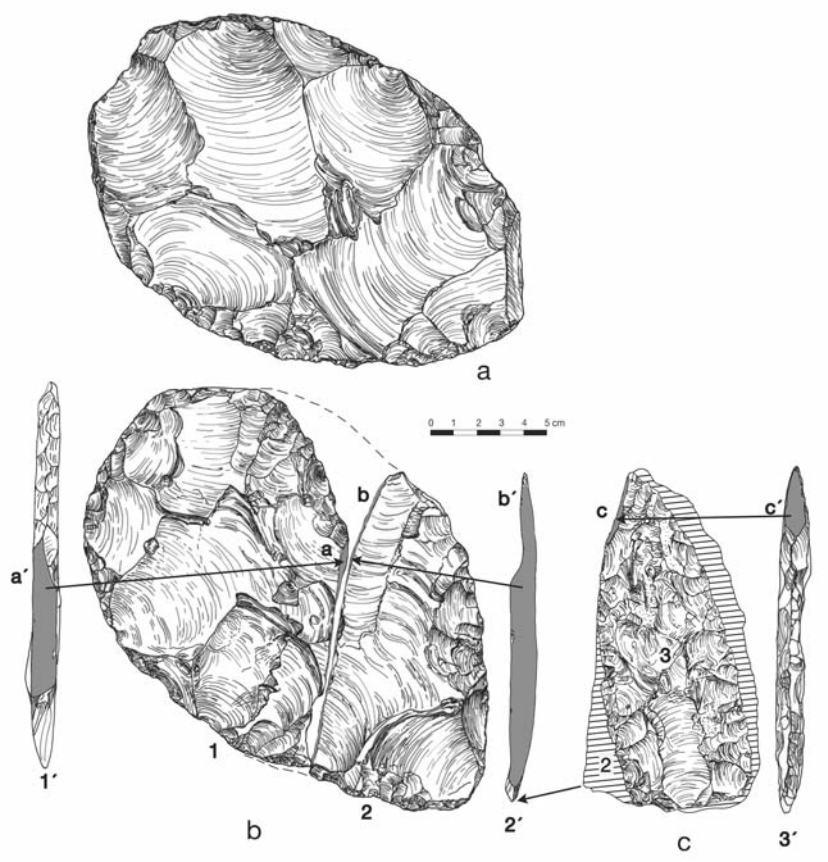


FIGURE 2.7.
Large bifacial flake cores: (a) unmodified core from Fenn Cache, Idaho; (b) biface core from Anzick Cache, Montana, that was deliberately broken into two pieces (1 and 2) to make a tool from fragment 2, such as the projectile point in 3c (hachured background of c is fragment b2); (c) early stage end-thinned biface from Anzick Cache; shaded areas a'-b'on figures 1' and 2' illustrate unmodified faces of b1 and b2 that were conjoined along the break surface of b1 and b2; c and c' of 3' are unmodified faces of c.

cores, to create flakes as large and elongated as possible (figure 2.7a). These cores were part of the mobile Clovis technology and provided a portable stock of stone material.[36] They were manufactured from the glassy stones obtained from local outcrops or gravel deposits. When a stone of suitable material was found, it was worked down to reduce its size and weight and to produce a desired shape. This process guaranteed the quality of the stone before it was carried away and made the core fairly compact and easy to transport. The core provided the raw material from which large, thin, flat, and straight flakes could be removed as needed.

The bifacial cores, reduced by the removal of flakes to make tools, eventually became too thin to produce suitable flakes. Depending on the size of the biface, it would then be made into a knife or a spear point. When the core was too large for a single point, it could

MASTERING THE ART OF OVERSHOT FLAKING

Controlled overshot flaking is harder than it sounds. As a beginning flintknapper, I found consistent biface thinning difficult to master and a source of great frustration. This process produced the most mistakes, used up the greatest quantity of good stone, and became an obsession. For years one of my most distressing actions was driving a flake too far and removing a chunk of the other edge. I frequently threw down the piece in disgust. What has now become known as overshot flaking was to be avoided at all costs. It wasn't until I saw the artifacts from the Sheaman Clovis site in eastern Wyoming that I got a glimmer of recognition that *some* overshot flaking may have been intentional. While studying the Sheaman flakes, the archaeologist George Frison recognized that some may have come from a single biface, and he set about putting them back together. He had found startling evidence that Clovis knappers not only recognized the value of overshot flaking for biface thinning but were able to control it. Once I experienced this epiphany, I tried to emulate the process. At that point I was a pretty good knapper, but I was humbled by the control and skill it takes to consistently apply overshot flaking, especially near the finish of an already flat, thin piece. After many years I still find it one of the most challenging techniques, but the idea that it is useful and can be controlled has finally achieved general acceptance among knappers, even though few have mastered it. *Bruce*

be broken (figure 2.7b) and the resulting pieces used to make two or more points (figure 2.7c). Pieces made from these fragments but not finished often retain a bit of the break in the form of a square edge (figure 2.7a', b', and c'). We should also point out that bifaces in various phases of production could be used as expedient tools, such as knives, when necessary. A multiple-use approach to stone use is extremely efficient for mobile groups, who only carried tested and useful stone.

Clovis biface technology is distinguished by the use of overshot thinning throughout the reduction process (figure Intro.5).[37] We think this technique had two main purposes: to massively thin and flatten the biface, and to produce large, flat flakes for use as tools. It was also a handy way to remove irregularities on an opposite edge, such as squared-off areas. Some projectile points exhibit overshot flake scars, including the results of removing the small portion of edge opposite the platform side.

Projectile point production, whether from pieces of large biface cores, unmodified raw material, or large flakes, followed the same general sequence: once a basic bifacial outline was achieved, thinning and regularizing became the main objectives. Although overshot flaking remained the primary approach, two additional but related techniques, normal thinning and full-face thinning, were also employed. Because overshot is difficult to ac-

MORE THAN POINTS

During the 1970s, working for George Frison on several Paleo-Indian sites in Wyoming, I first stumbled onto the observation that many Clovis biface thinning flakes had distinctive characteristics. We were working at the Agate Basin Site, in a locale where unidentified flakes were eroding from a bank. At first we found only flakes, many quite large and most of them biface. There was a range in size and form, but a large proportion had distinctive platforms and more or less parallel sides. What was noteworthy about the platforms, compared to what we were finding elsewhere, was that they were wide and straight. They were also heavily abraded. I remember being struck by their distinctiveness at the time. But it wasn't until the next year that further excavations at the site, now known as Sheaman, revealed that it was a Clovis occupation. Since the discovery of the Sheaman flakes, I have seen many assemblages that have the same type of platform. These assemblages come from sites all over the Americas, and without exception they have been determined to be Clovis. *Bruce*

complish and the outcome hard to control, platforms were individually made and carefully prepared to enhance success. The biface edge from which the flake was to be struck was turned or beveled toward the face from which the flake was to be removed. A segment of the turned edge was then isolated from the adjacent edges by the removal of small flakes from the flaking face until the striking platform protruded not only down toward the flaking face but also out from the adjacent edges. These carefully isolated platforms were centered on a ridge between two flake scars. Isolated Clovis platforms were relatively wide and straight, as opposed to the convex isolated platforms produced by many other thinning techniques. When flaking preparation was finished, the striking surface was heavily abraded. This abrasion commonly curved over onto the adjacent flaking face. Finally, force was applied with direct percussion. The angle of the blow had to be nearly parallel to the biface surface and strong enough to produce a large flake. Even if everything went just right, it took incredible skill to control the flake termination so that it removed only a small portion of the opposite edge. In our experience, this highly distinctive platform preparation and flake spacing has resulted in flakes that are as culturally diagnostic in Clovis as the finished points.

The second biface flaking technique used by Clovis flintknappers, full face, produced flakes that traveled most of the way across the face of the artifact and terminated smoothly at or near the opposite edge (figure 2.8a–c). This method was common but was done in conjunction with overshot flaking. It is actually the same procedure, just with "premature" terminations. Platform preparation remained about the same as for overshot flaking.

The third thinning technique, diving, was practiced by Clovis knappers to a lesser ex-

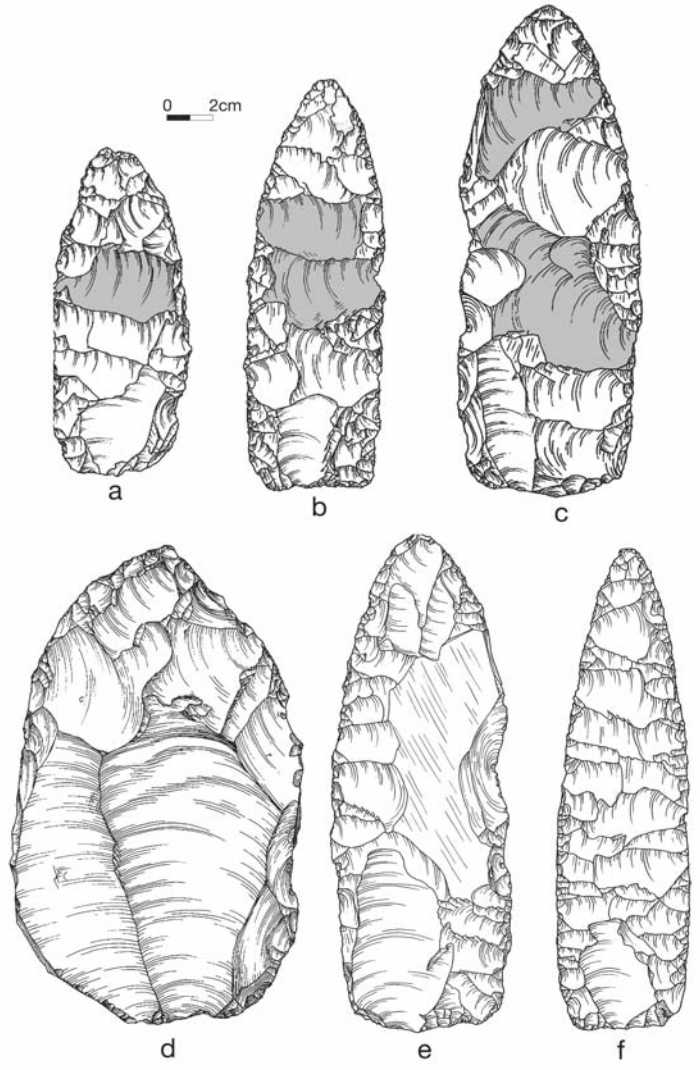


FIGURE 2.8.
Clovis biface thinning methods: (a–c) full-face flake scars; (d) early interval end thinning; (e) middle interval end thinning; (f) late interval fluting.

tent than the other two thinning techniques and consisted of driving flakes to the middle of the biface, ending in hinge fractures. These scars were then met by flakes coming from the other edge (see chapter 1).

Basal treatment of Clovis preforms was the same as the treatment at the sides. Bases were thinned by striking flakes from a bevel or isolated and ground platform. During the early and middle stages of preform reduction, basal thinning was part of the overall thinning process (figure 2.8d–f). The only real difference between side and base thinning was

that the central basal-thinning flakes followed a low convexity formed by flake scars originating on the sides of the preform. Also, because the bases are narrow relative to the width of the removed flakes, there is little choice of where the flakes could be removed, so both faces were thinned from about the same location.

Basal thinning brings us to the thorny issue of fluting. Along with biface thinning, probably the most sought-after skill in modern North American flintknappers is fluting. It can certainly be asked what the big deal is, if fluting is just thinning at the base. The challenge is that it incurs a much higher risk of breakage than lateral thinning. There are two reasons for this: the difficulty of striking the right spot, especially if the piece has an indented base, and the stress caused by hitting the end of a long, thin piece, which can result in a break across the middle (termed *end shock*).

Archaeologists and collectors have focused attention on a single characteristic of Clovis points, a distinctive flute scar on the finished pieces. It is unclear why the final basal thinning flakes (called *channel flakes*) were removed on most Clovis points in spite of the high risk of breakage. Large flakes were frequently removed to thin the bases of bifaces throughout the production process and not just during the final stages, indicating that those removed near the end of the sequence were not technologically different than the earlier ones. Examination of the platforms of the basal thinning flakes shows that they were prepared in the same manner as platforms for other biface thinning flakes. Technologically, flutes were just like any other major thinning flake and not an extraordinary invention.

Functionally, fluting thinned the base, facilitating the point's hafting onto a spear or foreshaft. But our experimentation with hafting and using fluted and unfluted points shows no significant difference in effectiveness. If fluting was a superior way of preparing a point for hafting, why wasn't it commonly used and reinvented many times? Clovis people themselves may have valued its symbolism as expressed by style rather than its function. Since fluting was a risky technique, perhaps the channel scars were retained to testify to the skill of the knapper. When finishing a fluted point it is easier to flake into the channel scars from the sides than it is to avoid intersecting them. An example of this is seen in the post-Clovis Dalton technology, whose pieces were fluted, sometimes to the tip, before the channel scars were almost completely removed by further flaking to finish the pieces.[38] We envision that fluting might have become part of a pre-hunt ritual.[39]

There is considerable variation in the way Clovis points were finished after fluting. Some have only minimal pressure retouch along the edges to remove major irregularities. Others show more extensive invasive pressure retouch. Still others have the entire circumference finished with abrupt bifacial retouch, leaving the large, flat percussion flake scars prominently visible on both faces. Finally, some Clovis points exhibit all-over pressure finishing that is well spaced and meets in a distinct midline. Examination of collections from throughout North America does not show these variations to be regional, and it is common to see all of them in collections from a single area. Thus, it is unclear whether

the differences have any meaning beyond individual knapper preference. Additionally, most of the points we find have been reworked, and the finishing techniques may not represent original manufacture.

Consistency does occur to the extent that even a group of points with different finishing techniques can usually be confidently identified as Clovis. Clovis fluting differs in concept and expression from the other fluted forms that are generally considered to appear later. Clovis channel flakes originated from the biface plane of the preform, and when both faces were successfully thinned the result was a base with a knife-like edge and both channels originating from about the same place.

Finally, Clovis points' lower edges were dulled by polishing or grinding. It is thought that this was a means of keeping them from cutting the lashings that held them to a spear shaft. This is not necessary for projectile points, however, and many later point types do not have edge grinding. But edge grinding might have been useful if a hafted piece was designed to be both a point and a knife. This was probably the case with Clovis points—but not Folsom points, which it's difficult to argue were designed to be knives, even though they also have ground edges. For Folsom, edge grinding might have been a traditional technological trait, or perhaps served a different function.

Along with bifaces, Clovis knappers had a well-developed blade technology, especially in eastern North America. Although we've seen a wide range of possible flaking approaches for bifaces, most North American archaeologists are unfamiliar with the equally diverse range of approaches in blade technologies in other parts of the world. In our experience, the manufacture of blades was just as complex and varied as biface technologies.

Mike Collins from the University of Texas at Austin published the first comprehensive description of Clovis blade technology, but even he agrees that he has only scratched the surface.[40] We have examined large numbers of Clovis blades, cores, and blade-making debitage (discarded pieces), and the following description is based on our impressions. More detailed analyses need to be done on the large collections from sites such as Gault in Texas and Carson-Conn-Short in Tennessee.[41]

We see two different blade-making technologies in Clovis, but they share a common goal and may be variations of the same general method. One approach to initiating blade making was to select a piece of stone with one or more long natural ridges—a flat nodule or a tabular piece—to create a core around. The knapper would build a platform above one of these natural ridges, and the first blade removed would have a natural dorsal surface (figure 2.9a). The second approach was to produce a single bifacial edge vertical to the axis of the nodule to serve as the initial guiding ridge (figure 2.9b). The first piece removed in this process is known as a crested blade. When blade precores are bifacially flaked all the way around their circumference, the resulting cores have a back ridge that is often retained throughout the blade-making sequence. In Clovis there is little evidence of this, perhaps an important distinction when looking for an ancestral technology.

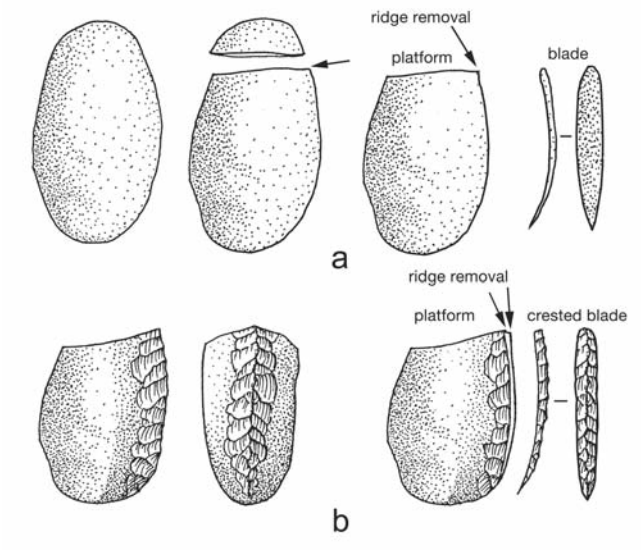


FIGURE 2.9.
Blade precore initiation methods: (a) using a natural ridge; (b) using a bifacially prepared ridge.

After the removal of the first blades, there was a wide range of possible choices for continued blade production. The most common approaches used throughout the world were continuing with a single platform, detaching most blades in a single direction; and with opposed platforms, striking blades from both ends of a core. Although we occasionally see blade scars originating from opposite ends of Clovis blade cores, it is clear that most blades were struck from the primary (proximal) platform, while those originating from the opposite (distal) end were removed while fixing mistakes.

Clovis had two blade technologies: employing a core with a single flaking face, and removing blades from the entire circumference of the core.[42] The first technique produced cores that are termed *wedge-shaped* (figure 2.10a). The discarded core remnants tend to be flat faced and have flat backs, with either a natural cortical surface or flake scars originating from the sides and meeting in the middle. A distinct aspect of Clovis blade making, especially from these wedge-shaped cores, is the apparent intent to make highly curved blades (figure 2.10b). This is unlike any blade-making tradition we are familiar with anywhere else at any time. In other blade technologies, heavily curved blades were the by-products of core face rejuvenation. This was necessary when the face of the core became too flat to remove another straight blade. A blade or blades had to be removed from one or more corners to make the face more convex, allowing for the removal of another straight blade.

Another characteristic of Clovis blade making is that the knappers often kept removing blades even when the core became so greatly reduced in size that it could produce only small blades. Some people call these *microblades,* but we prefer to reserve that designation for the highly formalized technologies where small blades were the primary product rather than just the end of the line of a large-blade technology. Hence, we refer to the

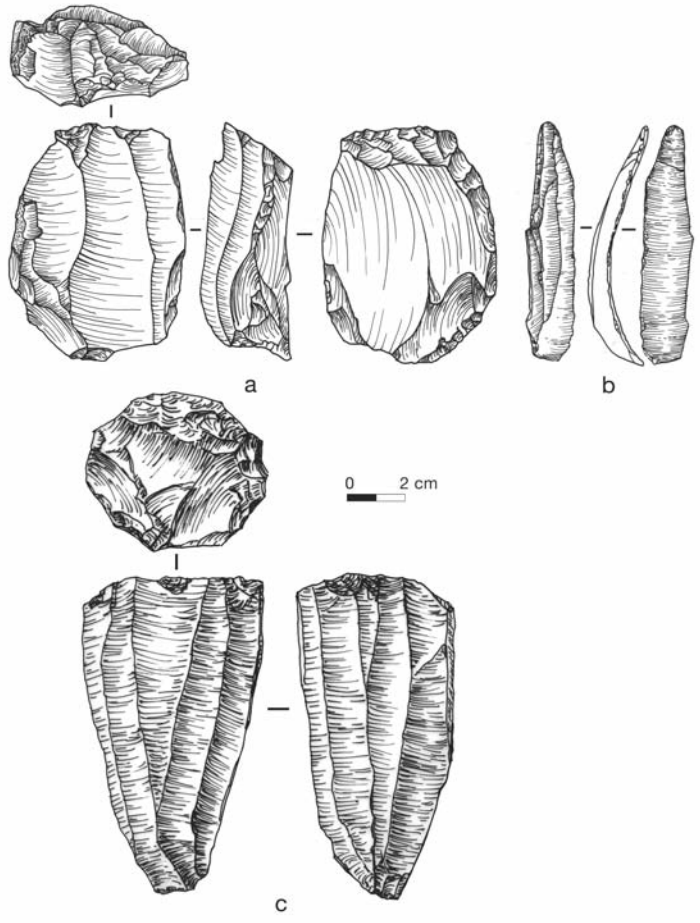


FIGURE 2.10.
Clovis blade cores and blade: (a) top, front face, side, and rear face of wedge-shaped core from the Gault Site, Texas; (b) front, side, and rear view of curved blade, Gault Site; (c) top, front, and rear view of conical core, Gault Site.

small Clovis blades as *bladelets*. This is a distinction made by Old World archaeologists as well. It is evident that Clovis people were intentionally making these bladelets, but their purpose has yet to be discerned.

The second blade-making approach is different in that the cores have blades removed from around their entire circumference. The resulting cores, described as conical (figure 2.10c), are roughly circular in cross section and taper toward the distal end. Their sequence of manufacture is unclear. They were probably made from large nodules or cobbles rather than shaped bifacial precores. It is also curious that many of the blade scars on these cores indicate that relatively straight blades were made from them, even though very few such blades have been found in archaeological sites. Perhaps straight blades were the intended product and most of them became tools that were subsequently used and modified to the

point that the original blade form was obliterated. A few end scrapers made on straight blades have been recovered, and many of the expended examples may have also been made on straight blades.[43] A few examples of other tool types made on straight blades are also known.

While conical cores are relatively uncommon, most are large and do not look as though they have yielded many blades. They could be blade precores that were made for export from the main quarry sites or campsites, but blade cores and debitage are rare at smaller camps and kill sites. It is also possible that some of the wedge-shaped cores were originally conical, though the lack of blade scars on their backs argues against this idea.

There is another curious characteristic of the conical cores: on most specimens the final flaking was the rejuvenation of the platform, a step usually subsequent to the removal of the last blade. Almost no negative bulbs of percussion remain on any of the blade scars on the cores. Since this core preparation happened after shaping, the objects we have found may have been precores rather than finished and discarded blade cores. It is also possible that the large conical cores were some type of tool. We would like to see use-wear analysis of conical as well as exhausted wedge-shaped cores, some of which could make excellent adze edges thanks to the angle between their platform and core face. A lot of work needs to be done before these blade technologies are really understood.

The remainder of the Clovis flaked stone technology is quite simple. Most blades or biface flake tools are unifacially retouched. Implements associated with kill/processing sites tend to be made on large biface flakes, with the retouching serving as both resharpening and tool backing. Although many of these pieces are called side scrapers, this simply indicates that the retouch is on the long side rather than the end (figure 2.11a). Microscopic examination of the edges indicates that most of these tools were used for cutting.

Certain types of borers (figure 2.11b), denticulated blades (figure 2.11c), gravers and multiple gravers (figure 2.11d–g), and end scrapers on blades (figure 2.11h–i) are fairly diagnostic Clovis tools. End scrapers made on flakes are often sub-triangular in outline (figure 2.11j), and some examples have a slight spur on one or both corners (figure 2.11k). Concave scrapers are present but not common (figure 2. 11l). Micro–end scrapers (figure 2.11m) and retouched blades (figure 2.11n) also appear but may be undercounted in some assemblages.

Borers are elongated drill-like tools usually made on flakes but occasionally made from broken bifaces and blades. This tool type is rare in the west and tends to be associated with large campsites. It was probably used to gouge out sockets and to drill holes in wood.

Denticulated blades are those whose edge or edges have been unifacially flaked to produce a series of notches that form a toothed pattern. Marilyn Shoberg has reported that microscopic examination of these tools indicates they were used for cutting meat.[44]

Gravers have a small, sharp point on the edge of a flake. Occasionally there is more than one point on the same tool, and these are termed multiple gravers. There is specu-

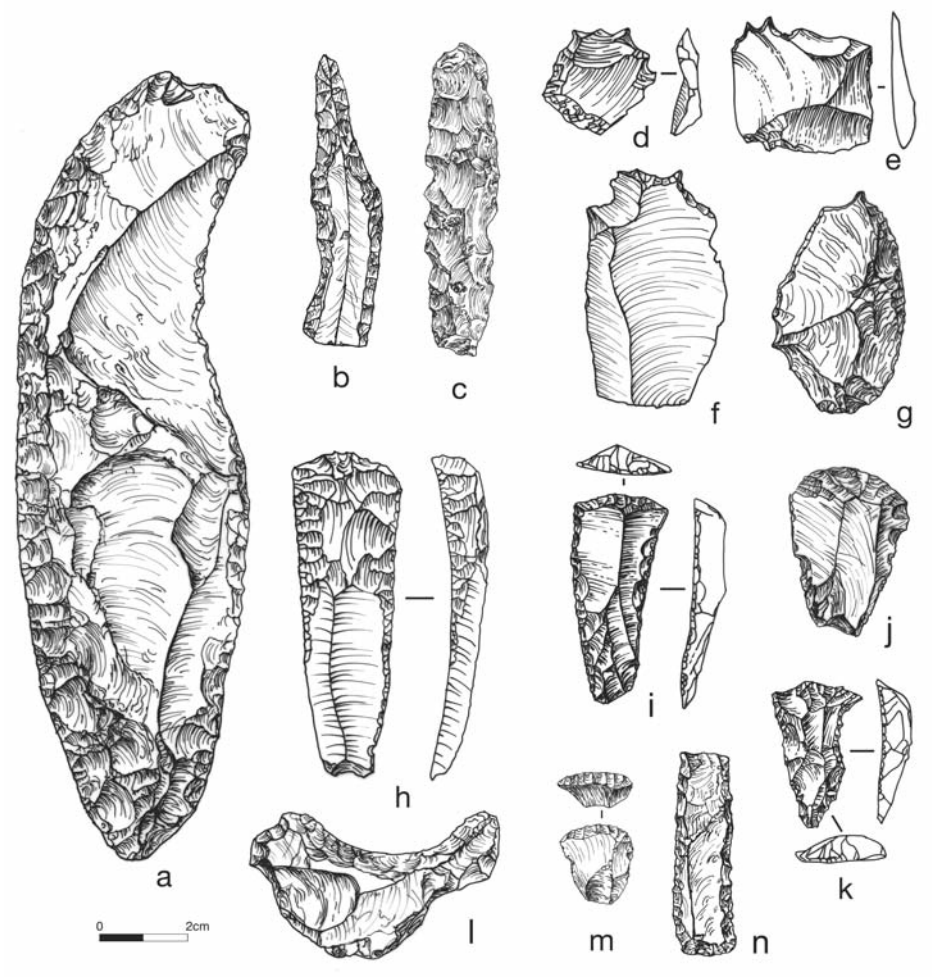


FIGURE 2.11.
Clovis flaked stone tools: (a) large side scraper/knife; (b) borer; (c) denticulated blade; (d-g) multiple point gravers; (h-i), end scrapers made on blades; (j) end scraper made on flake; (k) spurred end scraper; (l) concave scraper; (m) micro scraper; (n) retouched blade.

lation that gravers were used to engrave bone and other hard materials, but they are so delicate that they could only have been used on soft matter such as hide or leather. They do work well for incising designs on leather. Another suggestion is that they were tattoo needles. A microscopic study by the archaeologists John Tomenchuk and Peter Storck found that multiple gravers were used as compasses for drawing or etching circles.[45]

Adzes are an infrequently recognized tool type in Clovis assemblages (figure 2.12). These are relatively heavy tools that would have been hafted so that their working edge was perpendicular to the handle, like a hoe. They were usually highly formalized and are well described in the post-Clovis Dalton Complex in the southeast, but they have been recognized in Clovis assemblages only recently. For the most part, Clovis examples seem

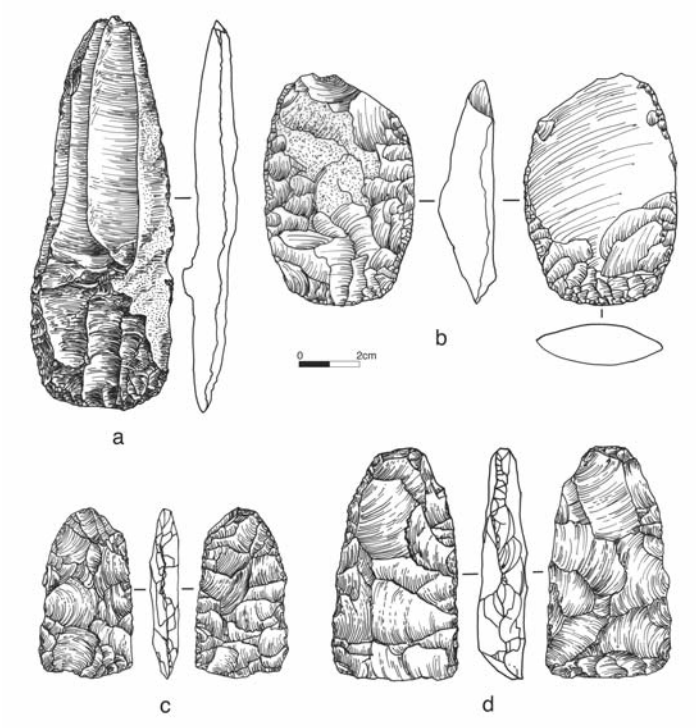


FIGURE 2.12.
Adzes: (a) East Wenatchee; (b–d) Gault.

to be less formal than Dalton adzes, but as more of the former are identified it is likely that this impression will change. Adzes are designed primarily as heavy woodworking tools, but they may be used for other tasks as well.

Burins are flaked stone tools produced by striking away a portion of a flake, blade, or biface in such a way as to form a nearly vertical edge and a chisel-like end. This implement is common in many Old World Upper Paleolithic assemblages and in some cases is the dominant tool form. So far they are rare in Clovis tool kits, but there is evidence of burin use on the edges of broken flakes and core ridges. It is possible that flakes were intentionally broken to produce edges that would serve as small planes and possibly engravers. These tools are called pseudo-burins.

Although eastern Clovis knappers knew about heat treatment to improve the flakability of raw material, they rarely used it, and the only evidence of this we are aware of in western Clovis assemblages is from the Anzick Site in Montana.[46] The Carson-Conn-Short Site in Tennessee contained great quantities of burned chert cortex as well as color-altered tools and flakes, suggesting that heat-treatment was used at this site, but more research needs to be done to verify this interpretation.[47]

ARTIFACTS MADE FROM PERISHABLE MATERIALS

With the exception of Florida, where underwater sites have provided excellent preservation conditions, Clovis sites have produced relatively few bone, antler, ivory, or other perishable material artifacts, so this significant aspect of Clovis material culture is relatively unknown.[48] Nevertheless, bone and ivory artifacts that exhibit substantial intentional shaping and modification have been recovered. Expedient bone tools—those that show use but little formal shaping—are also present in many Clovis sites, especially mammoth kill locations.[49]

Excavations in a site near East Wenatchee in central Washington that has been interpreted as an artifact cache have yielded an assemblage of stone artifacts and a group of bone implements. Of interest here are twelve bone tools that were recovered in direct association with large fluted bifaces and finished fluted projectile points. A thirteenth bone artifact remains in place, and there is evidence that a fourteenth was destroyed by carnivore activity. Although preservation is only fair to poor, some are well enough preserved for detailed description. Most, if not all, are slightly flattened cylindrical bone rods beveled on both ends (figure 2.13a–b). The bevels are always on the same side, but usually at slightly different angles at the opposite ends. These rods were made from mammoth limb bones or the antlers of large cervids. Some retain evidence of the cancellous tissue (the spongy interior bone), but grinding and polishing have obliterated the initial stages of manufacture. Most of the flattened, beveled surfaces exhibit shallow incisions perpendicular to the long axis of the rods. This hachuring (incised checkerboard-like cuts) is considered to be intentional roughening to aid in hafting, rather than decoration.

The bone rods vary substantially in size, with lengths ranging between 125 and 276 millimeters, with a mean of 225 millimeters. Widths range between 14 and 30 millimeters, but eleven of the twelve range between 24 and 30 millimeters. It is interesting to note that groups of rods have the same width measurements: three are 24 millimeters wide, four are 26 millimeters wide, and two are 29 millimeters wide. Altogether they have a mean width of 25.5 millimeters. If the smallest is not included, the mean width is 26.5 millimeters. Width was clearly more standardized than length.

Three of the double-beveled bone rods from the East Wenatchee Site exhibit simple decorative embellishment. Two have a zipper-like incised design along the midlines of their interior surfaces (figure 2.13a). Unfortunately, preservation is poor and details of the individual incisions are not clear. The third specimen exhibits small curved incisions on the back surface of the beveled end. These shallow incisions cover the surface and resemble fingernail impressions.

Mike Gramly, one of the archaeologists who investigated the East Wenatchee cache site, has proposed that the bone rods found there were composite sled shoes, tied together and lashed to wooden sled runners.[50] The bevels on the ends of the rods would have allowed enough overlap to produce a continuous composite runner. He notes that similar bone sled shoes were used by Inuits but readily admits that much more study needs to be done

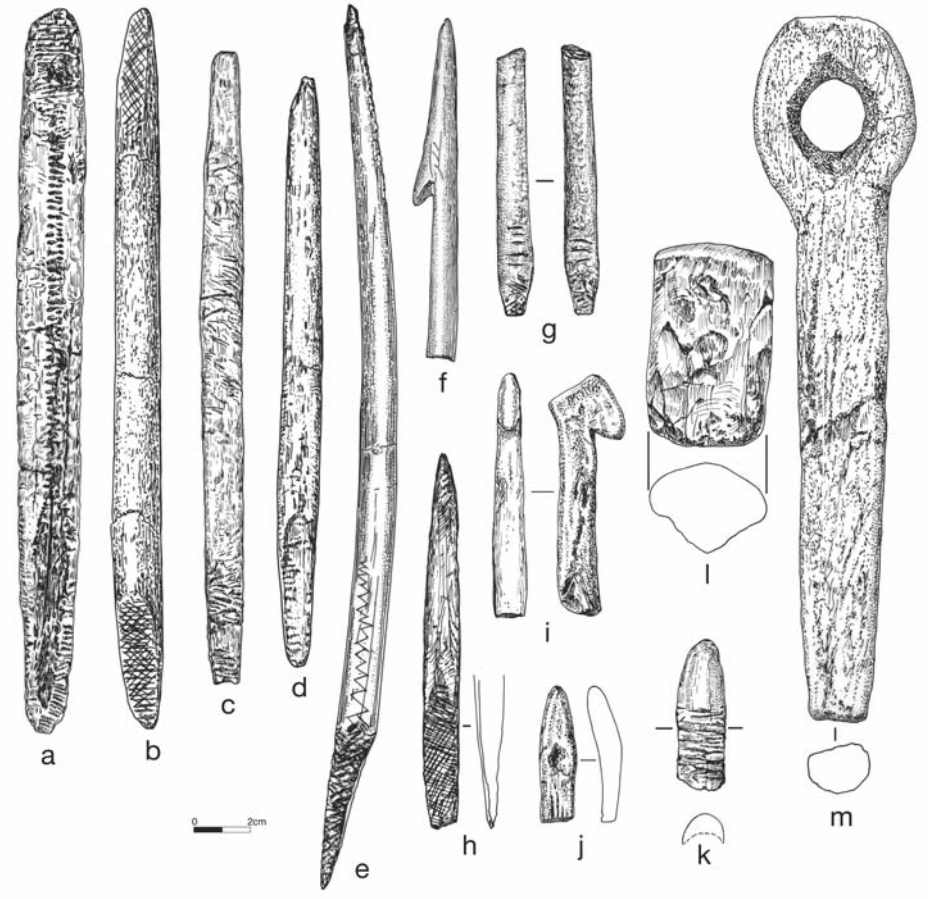


FIGURE 2.13.

Bone, antler, and ivory tools: (a) East Wenatchee decorated bi-bevel rod; (b) Anzick bi-bevel rod; (c) Anzick foreshaft; (d) Blackwater Draw point; (e) Florida decorated point (sagaie); (f) Florida barbed point; (g) Florida point; (h) Sheridan Cave, Ohio, point; (i–k) Florida atlatl hooks; (l) Blackwater Draw ivory billet; (m) Murray Springs, Arizona, shaft wrench. Outlines show (h) side view of base bevel; (j) section; (k–m) cross sections.

before this interpretation can be supported or rejected. We have difficulty accepting it. Skids for sled runners seem highly unlikely because of the complexity of the lashing that would have been required and the inevitable interference with traction that lashing would have caused. One might also expect distinct wear patterns to develop quickly, but there are none. Furthermore, the decorative embellishments would not have been visible.

Another Clovis cache site, Anzick in southwestern Montana, contained more than 132 artifacts and bone tools buried in a collapsed rock shelter.[51] This site was similar to the East Wenatchee Site, as it contained a large number of bifacially flaked stone artifacts, including Clovis points, a few unifacially retouched tools, and bone rods. A notable difference from East Wenatchee was the presence of the partial remains of two subadult hu-

man skeletons. The remains of a toddler consisted primarily of skull fragments, and the artifacts were all stained with red ocher. The other individual has been shown to be unassociated with the Clovis materials.[52]

Eleven bone rods were among the artifacts collected from the disturbed deposits of the site: two complete rods, four fragments with beveled ends, and five midsections.[53] One complete rod is much like those from East Wenatchee and is beveled at both ends (figure 2.13b). The other is beveled on one end only, with the opposite end indented and tapered mostly flat but slightly rounded (figure 2.13c). Six of the seven bevels are incised, primarily in a crosshatch pattern, and there was organic residue thought to be resin on the beveled ends.

The complete rods are about the same length as those from East Wenatchee, but they are proportionally narrower. They measure 220 and 281 millimeters in length, but the width at their widest point ranges between 15 and 20 millimeters, with a mean of 17.9 millimeters. As with the East Wenatchee specimens, there seems to be a greater standardization of width than length.

The archaeologists Larry Lahren and Rob Bonnichsen have hypothesized that the double-beveled bone rods from Anzick were foreshafts for spears.[54] Clovis points would have been hafted onto one of the bevels, and the other would have been lashed to a wooden main shaft. But hafting Clovis points onto the bevels of the bone rods by inserting a wedge would have produced a bulky and weak joint connection. Since this construction would have made penetration beyond the hafting area difficult, we think there are more plausible functional interpretations for these artifact forms.[55]

Five closely related Clovis sites have been excavated in the San Pedro Valley, Arizona, not far from the border with Mexico.[56] While three of these sites are animal kill and butchering locations, two, Naco and Escapule, may represent mammoths that died after being speared and eluding their Clovis hunters. The only formalized bone tool recovered from any of these Arizona sites was excavated at Murray Springs (figure 2.13m). It is 259 millimeters long, 21 millimeters thick, and shaped like an eyebolt. The head, 58 millimeters wide, has a hole 25–30 millimeters in diameter bored through the center. The handle is 34 millimeters wide where it joins the head and gradually tapers to an approximate width of 21 millimeters at the opposite end. The hole was purposely beveled, the most pronounced beveling being at the top and bottom on opposite sides of the tool. C. Vance Haynes Jr. and E. Thomas Hemmings have convincingly argued that this unique artifact is a spear or dart shaft straightener.[57]

Bone and ivory objects recovered during the excavations of the various Blackwater Draw, New Mexico, Clovis localities include roughly fashioned expedient tools made of mammoth bone and carefully shaped formal tools, also mostly made of bone. All of these were directly associated with flaked stone tools, including Clovis points, and with mammoth remains. Among the formalized artifacts are four points, an awl, an ivory billet, a possible flaker or ornament, and a bead preform.

Only one of the points is complete, and it has been identified as antler rather than

bone. It has an oval cross section and is beveled at one end and tapers to a point at the other. Oblique scratches are visible on the bevel. The pointed tip of this specimen shows impact fracturing, and because it was found associated with a mammoth carcass it is probably a projectile point (figure 2.13d). Its length and width are 237 and 17.2 millimeters, respectively, falling within the range of the bone rods from the Anzick Site. The other three specimens are fragmentary, but all closely resemble portions of the complete artifact.

An ivory tool found in the Blackwater Draw Clovis sediments was made from a short quarter section of mammoth tusk that was ground into a cylindrical shape (figure 2.13l). This tool is 46 millimeters wide and 34.8 millimeters thick and would have measured more than 73.5 millimeters long when complete. It has been described as a burnisher or a hammer used for flintknapping.[58] One end is slightly convex and polished; the other end is damaged by impact and longitudinal flake scars that are characteristic of hafted flintknapping hammers.[59]

Among the other bone tools is a small bone fragment that was ground to a narrow, sharp point to serve as a perforating tool for hide working or a basket-making implement. A small, rounded rectangle with perforations incompletely drilled from both ends is a possible bead preform. A fragment of a possible canine tooth exhibits polishing and has been interpreted as an ornament or flaker, but it is too incomplete to adequately assess its function.

A modified section of a mammoth tusk tip was also found at Blackwater Draw.[60] Although this is not a formal tool, it is an important specimen because it illustrates some of the techniques used by Clovis people to work ivory. The slightly curved section was removed by a sequence of scoring and chopping around the diameter of the tusk. After its cross section was reduced in mass, it was flexed until it snapped away from the rest of the tusk. It measures 730 millimeters long and 97 millimeters in diameter at the base. What sort of tool or tools were intended to be made from this piece of ivory is unknown, but it could have been further sectioned into beveled rods like those from East Wenatchee and Anzick or projectile points similar to those found in other localities at Blackwater Draw.

The Sheaman Site, in eastern Wyoming near the boundary between South Dakota and Nebraska, also produced a bone or antler rod in association with bifacial reduction flakes, a Clovis-like projectile point, several flaked stone tools, and bison bone.[61] All of these artifacts were concentrated slightly below a burned and buried paleosurface. The rod is a flattened cylinder that tapers slightly to a tip broken in a distinctive manner that suggests it impacted a resistant material with considerable force. The other end terminates in a flat bevel that is lightly incised with a crosshatch pattern. The artifact's length (not including the missing portion) is 203 millimeters, and it is 13 millimeters wide. Since it has impact damage reminiscent of the damage to the bone projectile point from Blackwater Draw and it is proportionally longer and narrower than the bone rods from Anzick and East Wenatchee, we conclude that it was used as a projectile point.

Numerous ivory and bone projectile points / foreshafts, locally termed *pins,* have been recovered from rivers and springs in northern Florida, but because of the acidic upland

soils typical of the southeastern United States, no carved ivory artifacts have been found in terrestrial Paleo-Indian sites in Florida. All of the Florida ivory specimens were found in submerged river channel locations that were inundated by inland water table rise during the Holocene. The largest concentration, which accounts for more than half of the sample, comes from the lower karst (limestone with cracks and caverns) section of the Aucilla River. Other river basins that have produced ivory objects include the Santa Fe, Ichetucknee, and Oklawaha.

Most of the known Florida ivory specimens have been recovered from stratigraphically mixed late Pleistocene deposits, where they are associated with extinct fauna, including mammoth and mastodon. Flaked stone projectile points found at these sites include Clovis fluted and an unfluted southeastern point type named Suwannee, some varieties of which are pre-Clovis.[62] Many of the ivory and bone implements are also points, and there are good indications, because of their extraordinary preservation, that they were made from fresh rather than fossil ivory and mastodon bone, strongly suggesting a direct association between humans and mastodons. The points are similar in shape and relative proportion to those from Clovis sites in the western United States. Generally speaking, they are roughly cylindrical and taper to a sharp point at one end. The opposite end terminates in a flat bevel (figure 2.13e). Recently an incomplete example with a single barb was found (figure 2.13f).

The length of these points is highly variable because after they were broken during use they were reworked into progressively shorter weapon tips, just like stone points. The best-preserved specimens show that their surfaces were burnished to slickness except on the beveled end, which was roughened and grooved for hafting. In addition, two of the ivory points exhibit incised decoration extending from the interior end of the bevel down the shaft toward the tapered end. One of these designs is a zigzag pattern (figure 2.13e), and the other is a series of parallel lines that run transverse to the long axis (figure 2.13g).

Jim Dunbar, an archaeologist who has researched these Florida sites, argues that the ivory tools were foreshafts with fluted stone points hafted to the scored bevel and the pointed end inserted in a socket in the main shaft.[63] His interpretation does not include a separate wedge on the opposite side of the stone point from the bevel, as suggested for the Anzick pieces. He bases this reconstruction on the breakage patterns observed on the artifacts. Although this hafting method would be less bulky than the wedge method, the connection between the stone point and the ivory foreshaft would be weak. Our experience with replicated Clovis weaponry indicates that penetration through the hide of an animal would have been severely impeded by either of these configurations. Thus, as with the Anzick hypothesis, we think that alternative interpretations are more plausible. For instance, taking the well-documented bevel-hafting method used by historic Inuit hunters as a model, we conducted experiments using ivory rods as projectile points and found that they are extremely lethal and penetrate thick modern elephant hide deeply with little difficulty. We think it likely that these were points, probably used on thrusting spears. Damage to many of them supports either interpretation.

There are other possible Clovis bone points, but because of poor preservation they are not common. A cylindrical bone point of unknown association was found in southeastern Saskatchewan in the early 1900s.[64] There are no dated geological or artifact associations for this specimen, but the probability that it was made from the long bone of a mammoth or mastodon and its resemblance to bone points of known Clovis age suggest that it was of early manufacture. Another long bone point has been described from Lower Klamath Lake in southern Oregon.[65] The presence of blue silt stains on the point and on associated mammoth bones suggests that they are contemporaneous. The similarity of this specimen to other artifacts of known antiquity also favors a Clovis-age origin. Finally, two bone points were recovered from Sheridan Cave in Ohio (figure 2.13h). Although they were not in direct association with Clovis artifacts, Ken Tankersley, the excavator of the site, has made a convincing argument that they are at least Paleo-Indian.[66] All of its characteristics fit well with the other Clovis bone points.

C. Andrew Hemmings has identified ivory objects from Sloth Hole, Florida, as atlatl hooks, the projections on the end of spear throwers where the spear was seated (figure 2.13i–k).[67] The discovery of these hooks supports the idea that Clovis hunters used these effective weapons for hunting big game. On the other hand, an expected artifact form in Clovis assemblages that has been elusive is an eyed needle. But two fragmentary specimens made of ivory were recovered from a river context in Florida. It is not possible to say that they were definitely associated with Clovis artifacts, but since they were made from fresh ivory and mammoths went extinct during Clovis times, this seems likely.

Not all bone tools need be made in formal styles. There has been a lot of controversy over the use of percussion flaking for the manufacture of expedient tools from the bones of large mammals, especially mammoths. Studies such as the Ginsberg experiment, the experimental butchery of an elephant, demonstrated conclusively that fresh, heavy cortical bone could be processed using techniques akin to stone knapping into cores that produce sharp-edged bone flakes.[68] Furthermore, a growing number of flaked mammoth bones are being found at Clovis sites, such as Lange-Ferguson in western South Dakota, where bone flaking has been identified and described.[69]

Several formalized bone and antler tools and manufacturing technologies have been documented for the Folsom period, 10,900–10,300 BP, which immediately followed Clovis on the High Plains of North America. Folsom artifact types include fluted projectile points; various kinds of flaking tools, including an elk antler tool that we think was used for fluting points; eyed needles; cut and incised bone disks and fragments (possibly ornaments or gaming pieces); and a hide flesher, a tool probably used to remove unwanted tissue from animal hides, made from a bison tibia. Virtually all of these materials have come from sites interpreted as base camps. Manufacturing techniques include grooving, incising, abrading, chopping, polishing, and drilling. Since Folsom probably derives from Clovis, it is likely that these artifact types and manufacturing techniques extend well back into Clovis times. We expect them to be found if and when Clovis campsites with good organic preservation are excavated.

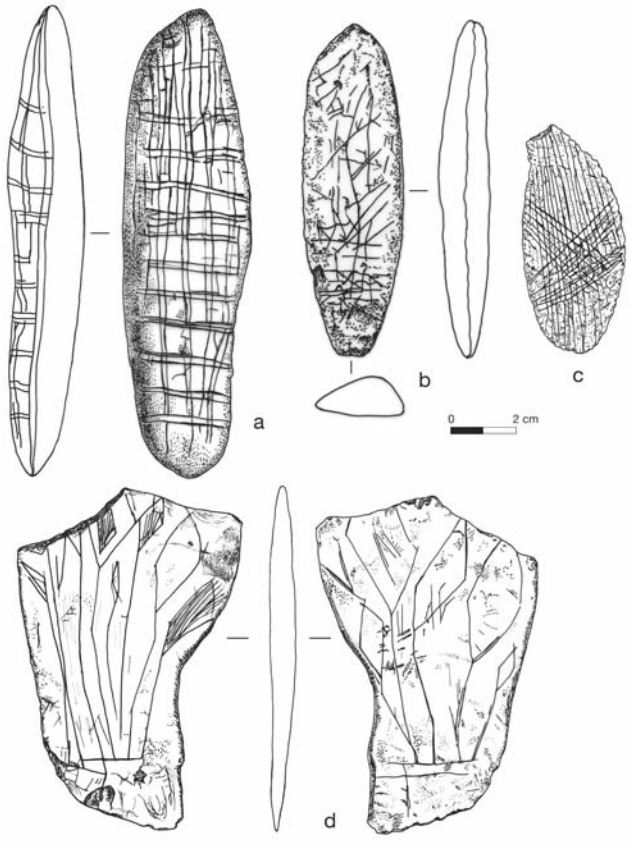


FIGURE 2.14.
Gault Site incised stones: (a) geometric; (b) possible zoomorphic; (c) crosshatched; (d) double sided, with spear fletching.

ARTISTIC EXPRESSION

Evidence of Clovis ornamentation is minimal and rare, and the representation of animals and humans in cave art is totally absent, with the possible exception of a couple of mammoth figures in the west. Although bone artifacts probably served a utilitarian function, some were decorated with incised hatching marks or zipper or zigzag designs, as noted above. It is possible that the double-beveled bone rods were conjoined into burial or other ceremonial objects.[70] Probable bone bead preforms and a tiny pebble with a natural hole in the center found in the Clovis level at the Shawnee Minisink Site in southeast Pennsylvania, as well as beads from Blackwater Draw, indicate that Clovis peoples probably wore decorative or ritual objects.[71]

Small incised stones have been recovered from the Clovis level at the Gault Site in central Texas.[72] These stones are mostly thin limestone slabs that are natural in the area. The incising is mostly geometric designs, especially hatching and crosshatching (figure 2.14a

and c), but at least two stones may be etched with animal representations. Some people think one of these resembles a running fox or a type of canine (figure 2.14b), and the other seems to represent several fletched spears stuck in an animal (figure 2.14d). The latter stone has the same basic design on both sides. Similar incised stones appear at other Clovis sites but are rare because of poor preservation in acidic soils or differences in site function or simply because they have not been recognized. However, a figure of a mastodon was recently found incised in a fragment of a mastodon long bone eroding out of the sediment at Viro Beach, Florida (figure 7.7h). While it has no direct association with Clovis, it was likely produced during that time or possibly even earlier.[73]

3

BERINGIA

Out of Asia on Foot

The well-known Beringian land bridge / ice-free corridor theory was originally put forth on the basis of geological studies of the timing and extent of the great North American glaciers, as well as the lowering of the sea level, as a logical explanation of the peopling of the Americas. The archaeological profession quickly adopted the theory because it explained how hunters too primitive to have watercraft could have crossed the Bering Sea. With each retelling, in schools, books, and public lectures, the theory took deeper hold, eventually becoming dogma, and generations of professors have taught it to accepting students. The idea that people walked from northeast Asia to present-day Alaska was transmuted into certainty and is still recognized by many as the only answer to the question of where all prehistoric people in the New World originated. A great deal of research in Alaska and more recently in Siberia has focused on finding the evidence to prove it, without much to show for the effort.

BERINGIA AND THE LAND BRIDGE

Beringia is the name given by scientists to a massive extent of land that surrounded the Bering Strait, the narrow gap of ocean that separates the northeastern tip of Siberian Russia from the western point of Alaska.[1] During the last ice age, sea levels were much lower than today, exposing large sections of ocean floor. As they emerged, the world's continental shelves created new coastal landforms, including the Bering land bridge, which linked Asia and North America. The surrounding region, Beringia, extended east as far

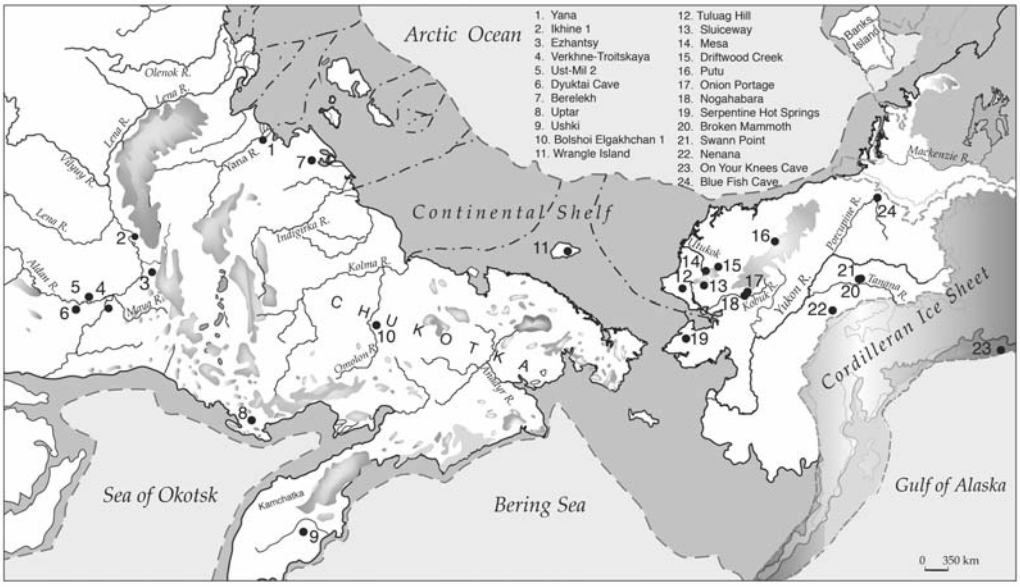


FIGURE 3.1.
Map of Beringia showing sites mentioned in the text.

as the edge of the continental glacier near the present-day Mackenzie River and south to the northern terminus of the Cordilleran ice sheet in the mountains of southern Alaska (figure 3.1). Westward it stretched across Siberia to the headwaters of the Lena River and then angled southeast into the Russian Far East. Beringia is nearly twice as wide to the west of the Bering Strait as it is to the east. People traveling by land from Asia to North America would have had to cross this vast, treeless Arctic plain, which was icy during the long, dark winter and wet and buggy during the short summer months.

Quite a few reasons and quite a few assumptions make the land bridge crossing the dominant theory of the peopling of the New World. Some are based on sound science, others on intuition. For example, it seems reasonable to think that because modern Native Americans look Asian and possess Asian genetic traits, their ancestors must have all come from Asia. But this assumes that all ancient Americans looked like modern Indians and that the earliest people who migrated from northeast Asia must have looked like those who reside there today. Since virtually no late-glacial-age human remains have been found in either North America or northeastern Asia, it is difficult to test this assumption.

Another supporting idea is based on early research indicating that near the end of the last ice age, the two major North American continental glaciers had melted far enough apart to create a passable ice-free corridor from Alaska to the plains of southern Alberta.[2] This date for an opening would have allowed enough time for the establishment of an environment that supported plants and animals as well as the Clovis ancestors working their way southward to reach the Lower Forty-Eight. Recent paleoecological and geolog-

ical research has provided persuasive evidence, however, that the biogeographic corridor was not established until sometime between circa 12,000 and 14,000 years ago.[3] In our opinion this date for the opening would have been much too late to allow for the pan-continental distribution of Clovis technology by 13,000 years ago. Nevertheless, the impact of the original concept lingers, as in this recent statement by the Arctic archaeologist F. H. West: "Had there been no corridor southward or had that corridor lain to the east of the continental ice sheet, it seems certain that the discovery of America would have had to await the coming of navigators from over the seas."[4]

This statement by West includes another assumption, namely, that early hunters could have crossed the Bering Strait only by dry land, because they had no watercraft. Thus they would have been unable to cross even a small stretch of water—or, in West's view, to walk across a frozen expanse of sea. This, of course, has not been the case in more recent times. Many Holocene groups have crossed the Bering Strait, and Inuit people have gone back and forth frequently in historic times, either in skin boats or over the ice by foot or with dog teams.

Also implicit in the land bridge concept is the conviction that the High Arctic landscape would have been habitable and amenable to foot travel during the Last Glacial Maximum (LGM). Reconstructions by vertebrate paleontologists portray much of the area as being a shrub tundra environment with a diverse community of large game animals.[5] Some palynologists, by contrast, read the plant evidence as indicating a bleak, polar desert.[6] Other researchers envision much of the region as cold, moderately dry to moist environments with heaths, dry meadows, and shrub tundra interspersed with marshes and small ponds.[7] No matter what the climate, the low-lying topography of the land bridge would have been poorly drained in summer and covered with meandering rivers, lakes, ponds, and marshes, making it one of the least desirable land surfaces known for foot travel. Regardless of its specific physiography, most researchers concede that the land bridge was probably harsh and difficult to traverse.

Even today northeastern Siberia is the coldest place on earth, with prolonged and severe winters with temperatures as low as -94°F, exceeding the average low temperature of Antarctica, and short summers with average July temperatures of 59°F.[8] In the Late Pleistocene the climate was even more extreme. And along with adverse paleoecological conditions, there were many large rivers, rugged mountains, local glaciers, and numerous other obstacles to foot travel. We can only imagine what challenges this area must have presented during the Late Pleistocene.

Newspapers, books, magazines, and museum exhibits have repeatedly illustrated ice age hunters as primitive people who dressed in rudimentary animal skins and eked out their survival with spears and clubs, creating the comic strip conception of the caveman and the die-hard notion that cavemen coexisted with dinosaurs. But even in today's climate, people who dressed and lived like that would not live long. Therefore, we suggest that ice age people had cold-weather technologies at least as sophisticated as those required for survival during the warmer conditions of the Holocene, a geological epoch that

began around 12,000 years ago. At the very least, tailored, waterproof clothing was a necessity, along with substantial all-weather shelters. With the skills to create these items, they no doubt also had the ability to construct sewn-skin boats. One has only to ask whether the peoples who live in Arctic conditions today could survive as they do without adequate clothing, shelter, or boats to cross and travel on rivers and lakes. Lacking good archaeological evidence to the contrary, we assume that this knowledge was integral to successful Arctic colonization.

Another relevant aspect of Beringia is that because much of it is above the Arctic Circle, at 66 degrees north, cultures there must adapt to months of darkness alternating with months of continuous daylight. Why would anybody move into such a region? To answer this question, we need to examine the late Pleistocene archaeological record on the Siberian and Alaskan sides of Beringia. Fortunately, several relevant works are available. One of the most complete, *American Beginnings,* pulls together much of the information, and we take advantage of this source in this chapter's review, unless otherwise indicated.[9]

Virtually everybody who has attempted to summarize the archaeological data from Beringia has employed many qualifiers, because the research is characterized by different theoretical approaches and analytical methods.[10] This is partly because of the length of time over which the work has been accomplished but also because of major differences between Soviet and American archaeological approaches to survey coverage and intensity of excavation, as well as what questions are asked and what analytic criteria employed.

Another difficulty is that we are looking at a part of the world that has never been densely occupied. Most archaeological sites were temporary and probably used by small groups of people. As elsewhere, durable material culture represents only a small fraction of what people used, and little of it was left behind at any one place or time. This means that most ancient sites have small artifact inventories, and these represent few of the activities undertaken by the inhabitants. Furthermore, with the exception of rare sites where artifacts and other cultural remains are preserved by permafrost, the Arctic environment is as destructive today as it was during the ice age. Freezing and thawing, solifluction (the movement of saturated sediments on top of frozen deposits), ice wedges, and other frozen-ground phenomena, as well as tectonic uplift, isostatic subsidence and rebound (movements of deposits related to glacial compression and release), erosion, rising and falling sea levels, and shallow sedimentary deposition, are all destructive forces prevalent in the Arctic. All of this results in either archaeological sites with little to no stratigraphy or soil levels that tend to be disturbed and mixed. Thus, most Arctic sites are scatters of artifacts from multiple time periods found mixed on the surface or in shallowly buried contexts. Inaccessibility, short field seasons, and relatively high expense have contributed to the difficulty of doing fieldwork in the north. With all of these handicaps, it is fortunate that we can say anything about the prehistory of Beringia.

We commonly hear that Beringia is so vast and inaccessible that our current knowledge is based on a small fraction of what could be discovered. This is obvious, but not

unusual in archaeology. The American southwest has great preservation and a hospitable climate, and its sites are readily accessible compared to those of the Arctic. Yet we have estimated that even in southwestern Colorado, where fieldwork has been conducted for more than one hundred years, less than 1 percent of the available record is well enough known to contribute to modern research interests. Even so, archaeologists must not refrain from interpreting the available record if we expect to make any scientific headway.

What do we know about the late Pleistocene and earliest Holocene archaeology of Beringia? Although it is a vast geographic area, it has been significantly explored and archaeologically surveyed. Investigations tend to focus on the more accessible areas, but if they are convenient today, they were probably used in the past. This is especially true of prime spots on rivers and in river valleys, where fordings, portages, and other transportations were easier, then as now. In eastern Siberia, surveys and less formal explorations have recorded archaeological sites along most of the major rivers and their tributaries. This is also true of much of Alaska and the ice-free part of the Yukon. Of course, a lot of the area has not been examined intensively, and unknown cultural traditions may be waiting to be discovered. New discoveries are being made: for example, the Yana Rhinoceros Horn Site of far western Beringia, some 2,200 kilometers from the Bering Sea coast.[11] Dating to 30,000 years ago, this site is the first evidence of pre-LGM habitation in the High Arctic. This is an important discovery, but does it relate directly to the New World colonization issue? At present the answer is unknown, but based on the flaked stone technology found at Yana, a relationship to Clovis seems highly unlikely.

The archaeological data from Beringia can be compiled in several ways. One is to group sites according to artifact assemblages, a common approach since many sites lack radiocarbon dates. Those with similar tools and technologies are considered related historically and presumed to be of a similar age. Their chronological placement is established by comparisons with similar archaeological sites that have been dated. Considering the geographic distribution of sites related technologically creates additional clusters, which archaeologists describe as "cultures" based on various criteria such as tool forms, settlement patterns, and technology. These are not the same as what we might consider cultures today, and there is no assurance that prehistoric people would have recognized our archaeological cultures. For example, the Clovis culture has meaning in terms of its archaeological characteristics, but this doesn't necessarily mean that Clovis people would all have spoken the same language or believed the same things. Cultures are just a convenient way for archaeologists to communicate. Once established, they can be plotted in time and space and their distributions used to reconstruct the culture history of the region.

WESTERN BERINGIA

With the exception of Yana, the earliest artifact assemblages in Beringia belong to a generalized Asian microblade tradition. (*Tradition* in this case refers to a shared technology but not necessarily other traits that would qualify it as an archaeological culture.) These

early assemblages are classified as the Early Dyuktai Culture. Five sites with Early Dyuktai material have been dated, and quite a few other sites have been classified as Early Dyuktai by the composition of their assemblages. With the exception of Ust Mil 2, where some anomalous older dates were recorded, all of these sites fall between 18,000 and 20,000 years BP (before the present), within the LGM, and all are in far western Beringia. Straight-line overland distances from them to the Bering Strait range from 2,200 to 3,200 kilometers and average more than 2,750 kilometers.

Artifact assemblages vary across these sites, but all are dominated by microblade technology, with wedge-shaped cores made on flakes (figure 3.2a) or bifacial precores (figure 3.2b). The accompanying tools are retouched microblades and blade insets, while the next most common tools are burins, made from both flakes and blades (figure 3.2c). Less common are bifacial knives (figure 3.2d), drills/borers, pebble tools, and side scrapers. Bone and ivory artifacts are rare. They include an ivory needle without an eye, encountered in the 18,000-year-old Verkhne-Troitskaya Site. A possible antler hammer from Ezhantsy is around 17,000 years old, and a bone awl from Ikhine 2 may be as much as 30,000 years old but is more likely around 20,000 years old.

Late Dyuktai assemblages, dating between 10,000 and 13,000 years BP, differ from Early Dyuktai assemblages primarily in an increase in bifacial knife and point production. Microblade technology still dominates, and there is an increase in the presence of microblade insets (figure Intro.3.a–b). Burins are present (figure 3.2f–i). Bifacial manufacture of microblade cores and precores becomes more common (figure 3.2 j–m), and bifacial techniques are used to create finished tools (figure 3.2e). Percussion bifaces are reduced proportionally (see chapter 1 for a description of this method), with rare cases of thinning. Bifacial points were initially percussion shaped and frequently pressure finished, producing thickened cross sections. Fine pressure retouch is rare, and lower-edge grinding of projectile points is unreported.[12] The only bone artifacts yet found in a Late Dyuktai collection are a possible projectile point flaked from mammoth ivory and an antler hammer from Dyuktai Cave.

Four Late Dyuktai sites have been dated in western Beringia, but like Early Dyuktai sites they are far from the Bering Strait—2,100 to 3,400 kilometers away, with an average of 2,825 kilometers. Several Late Dyuktai–like sites described by the archaeologist Anatoli Derev'anko are very close to the Bering Strait, but they might just as easily be related to the Denali tradition of eastern Beringia (described below).[13] In spite of the intervening Bering Strait, they are geographically closer to Denali sites then they are to any of the dated Late Dyuktai sites.

Several sites in western Beringia do not fit in the generalized Dyuktai tradition. Either they lack microblade technology or it is only a minor component of their flaked stone repertoire. Most of these sites are near Vladivostok, in the part of the Russian Far East known as Primorye, more than 4,000 kilometers by land from the Bering Strait. Radiocarbon assays of several of these sites indicate that they were occupied between 9,000 and 12,000 years ago, and little evidence has been found that their inhabitants spread

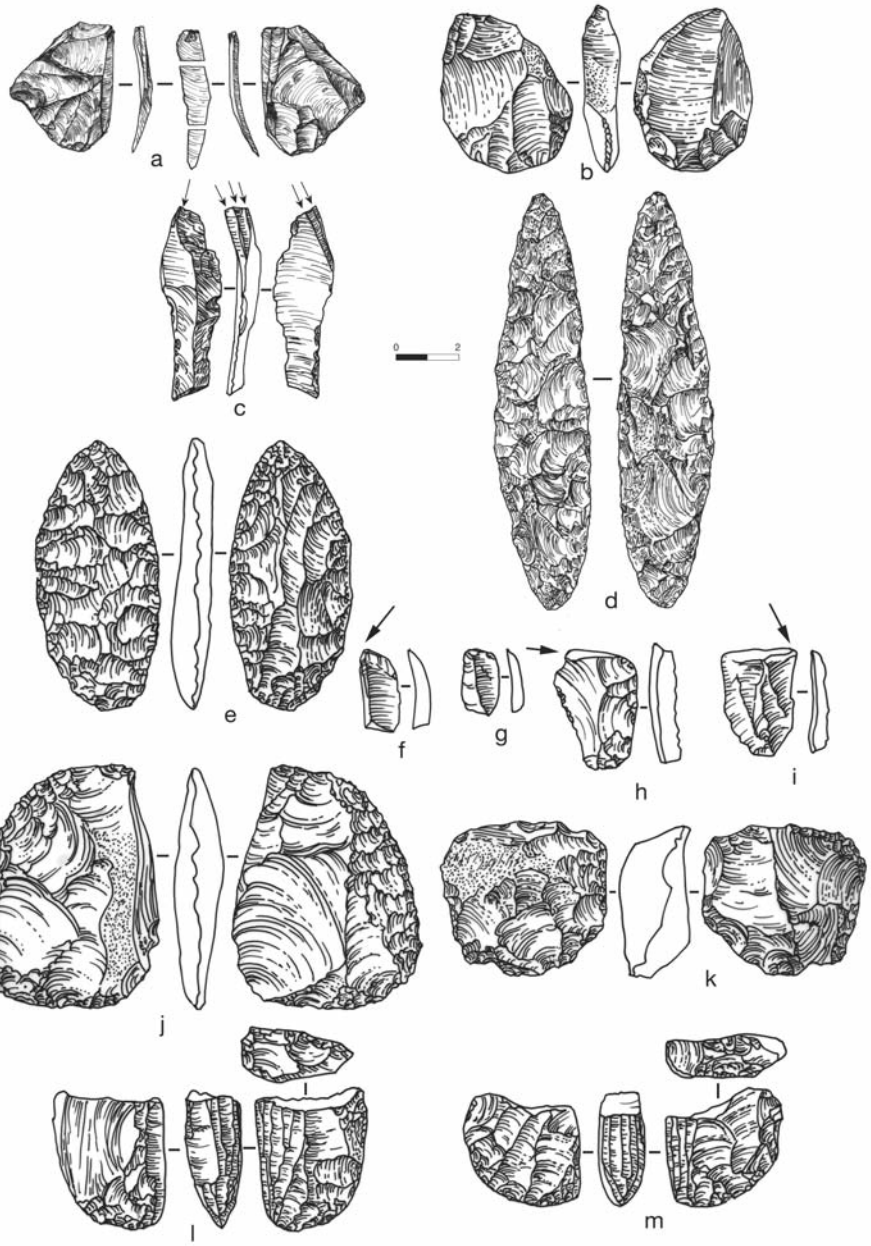


FIGURE 3.2.

Early and Late Dyuktai artifacts. Early Dyuktai artifacts from Dyuktai Cave: (a) wedge-shaped core with microblade; (b) obverse, cross section, and reverse sides of precore; (c) obverse and reverse sides of burin, with arrows showing direction of spall removal; (d) biface knife. Late Dyuktai artifacts from Level V, Leten Novyy Site: (e) biface; (f–i) burins; (j–k) microblade precores; (l) microblade core. Late Dyuktai artifacts from Kurung Site Layer VI: (m) microblade core.

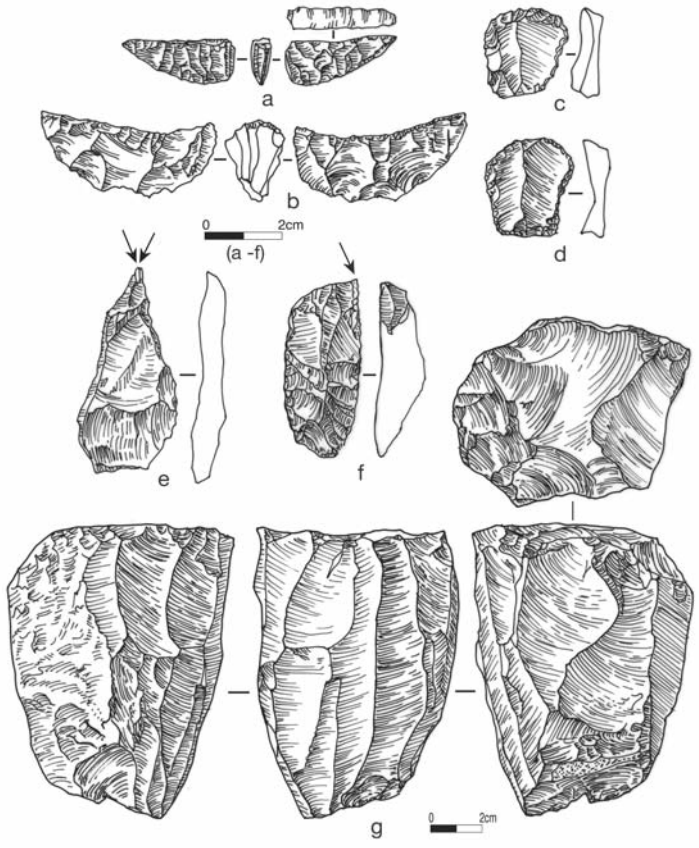


FIGURE 3.3.
Primorye artifacts: (a–b) microblade cores; (c–d) end scrapers with cross sections; (e–f) burins, with arrows showing direction of spall removal; (g) conical blade core.

north and east before 9,000 years ago, if at all. Their technology was based on large blade production (figure 3.3g), although flake tools are also present in significant proportions. Retouched tools, most of which were made on blades, make up only small percentages of the assemblages, dominated by end scrapers (figure 3.3c–d) and burins (figure 3.3e–f). Rare tools include perforators, possible unifacial points, and an occasional proportional biface. A few microblade cores (figure 3.3a–b) and some microblade core debitage are present in these assemblages, but it is not clear if the Primorye flintknappers used the Dyuktai technique to produce pressure microblades.

Two sites stand out as having non-Dyuktai components. Ushki, on the Kamchatka Peninsula, has a typical Late Dyuktai component in Level VI (figure 3.4a–i) underlain by Level VII, which contains a unique flaked stone assemblage (figure 3.4m–t). It is characterized by small, thick, bifacially flaked stemmed projectile points, which were finished by pressure flaking (figure 3.4m–p), and also contains burins (figure 3.4s), foliate bifaces

(figure 3.4a–c and r), and unifacial knives (figure 3.4t). N. N. Dikov, the original investigator, reported that microblade technology was absent, but the presence of percussion bladelets suggests to the Siberian archaeology experts Z. A. Abramova and Roger Powers that a microblade core technology was indeed used at the site (figure 3.4q).[14] This assemblage is like no other described in the region, but a few stemmed points similar to those from this Ushki collection have been found in small numbers at undated surface localities (figure 3.4j–l). Level VII was originally dated to around 14,000 years BP, but a recent reanalysis clearly demonstrates that it is only 13,000 years old.[15]

The other non-Dyuktai site, located above the Arctic Circle and known as Berelekh after the river nearby, has a bone assemblage that dates to between 12,500 and 13,000 years BP. It is best known as a paleontological locality that produced large quantities of mammoth and other Late Pleistocene animal remains. Most of the cultural artifacts were collected during large-scale bone-digging operations, and few were found in good context. It is probable that more than one archaeological component is represented, given the heterogeneity of the flaked stone collection. Though bifaces dominate, a single microblade core was recovered from the mining spoil. The bifaces include well-made fragments that were probably used as knives. There are also some small-point fragments pressure-flaked from thin flakes that closely resemble the Chindadn-style points found in central Alaska (see below). The recovery methods—mainly high-pressure water blasting—and probably mixed nature of this site make it difficult to place chronologically. The Russian archaeologists Y. A. Mochanov and S. A. Fedoseeva conclude that it was probably a very late Dyuktai occupation.[16]

The Berelekh Site was relatively rich in perishable osseous tools. The collection includes four mammoth bone knives, one leaf-shaped ivory projectile point, two scrapers, and several ribs with abrasions that may indicate use as burnishing tools. Mochanov and Fedoseeva state that these bone artifacts exhibit the same fine pressure flaking seen on the stone points. This is curious and makes us wonder whether the ivory and bone were mineralized when modified. The paleontologists N. K. Vereshechagin and V. V. Ukraintseva also think that the inhabitants of the site used bones mined from fossil deposits as a raw material source for artifact manufacture.[17] Although experiments to study the tool-manufacturing flaking properties of large bones—for example, from elephants—have shown that it is possible to make large flakes on dense bones, our experience is that pressure-flaking unmineralized bone is impossible because bone and ivory rapidly lose their workability, even when well preserved. If we are right, the purported pressure flaking on this bone indicates that it was mineralized and that it is not relevant to the dating of the site.

Berelekh is also famous for yielding a fragment of mammoth bone incised with the figure of a mammoth, which suggests that the artist who made the etching saw a live mammoth or even hunted one. It must be remembered, however, that frozen mammoths are commonly found even today melting out of the Siberian permafrost, and the artist may have used a long-frozen specimen as a model. We also know that mammoths were around during Clovis times and that they survived on Wrangle Island, in the Arctic Ocean

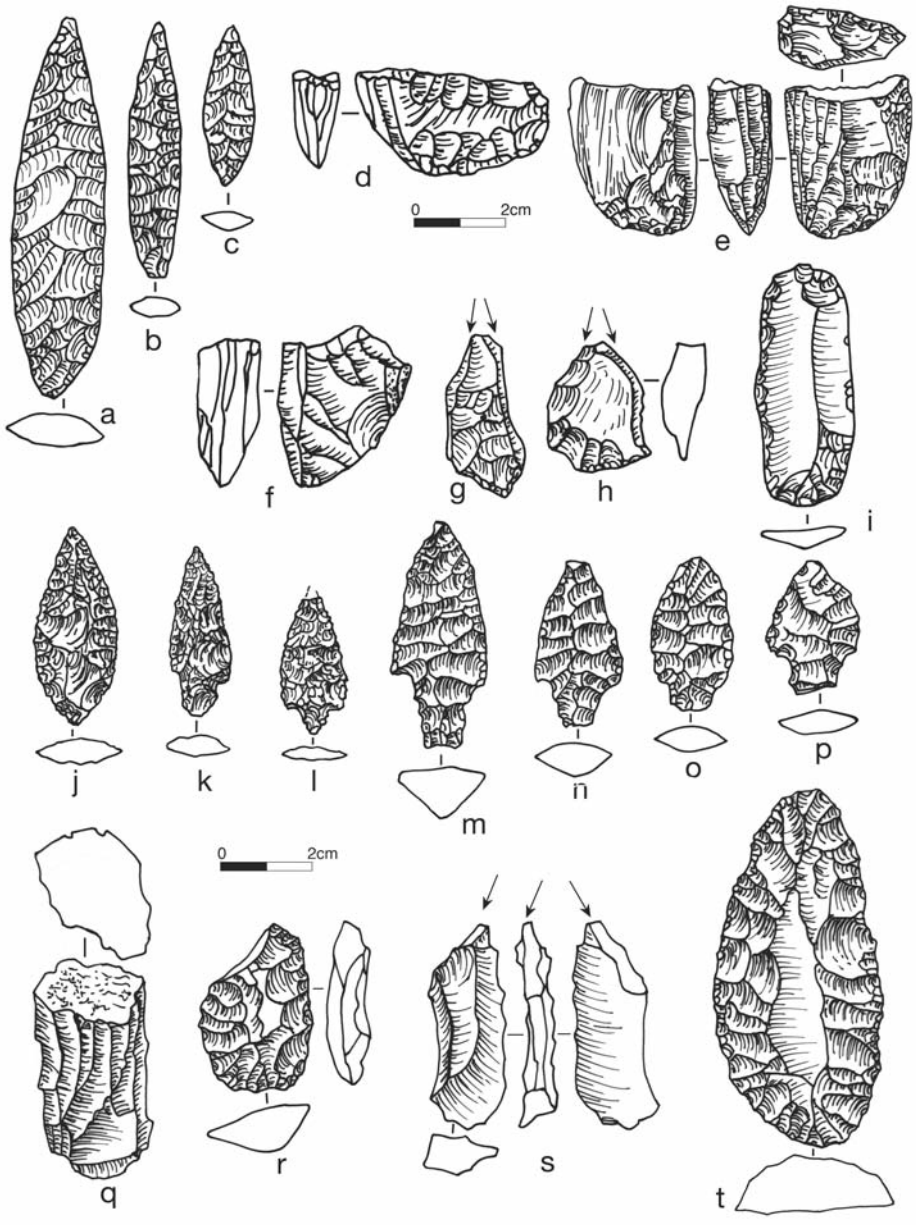


FIGURE 3.4.

Akmak artifacts from Ushki Levels VI and VII and Bolshoi Elgakhchan: (a–c) Ushki Level VI projectile points; (d–f) Level VI microblade cores; (g–h) Level VI burins; (i) Level VI end scraper; (j–l) Bolshoi Elgakhchan projectile points; (m–p) Ushki Level VII projectile points; (q) Level VII microblade core; (r) Level VII foliate biface; (s) Level VII burin; (t) Level VII uniface knife. Arrows show direction of spall removal.

northwest of the Bering Strait, until long after Clovis times, so this engraving does not necessarily indicate the artist saw a mammoth at a Clovis date.[18]

It is difficult to assess what all of these bone tools represent culturally, since most of them were found during paleontological salvage operations carried out mainly by high-pressure water excavation, which thoroughly mixes everything. Although the fossil bone deposit is dated to around 13,000 years BP, the human occupation of the site may have been much later. Vereshchagin and Ukraintseva suggest that the occupation evidence was recovered from a depth of 1.5 meters, rather than 2.5 meters as originally reported, and that the human occupation of the site probably occurred around 10,000 years ago.[19]

Stone pendants and beads are present in some western Beringian Late Dyuktai sites. Eight hundred stone beads were found in Ushki Level VII in association with a human burial (the bone was all but gone), and three stone pendants came from the same level. The younger Ushki Level VI produced several stone pendants and a flat pebble with scratches that, to those with good imaginations, could depict tents. Five stone pendants were found at Berelekh, but their provenances are also questionable. If they were associated with the cultural occupation level, they would be presumed to date to around 10,000 years BP. Two of the pendants have short incised lines or notches along their edges, and all have conical holes, drilled from opposite faces, that meet in the middle, producing an hourglass shape.

It appears that the cultural sequence of western Beringia is relatively straightforward. The Late Paleolithic flaked stone technology is dominated by an inset microblade tradition that is totally absent from Clovis. The few examples of bifacial projectile point technology are either insecurely dated (Berelekh) or have proved to be younger than Clovis (Ushki VII). Although there are local variations within assemblages and technologies, we contend that these variations are minor and are to be expected in such a large region as technologies evolved through ten millennia.

Early Dyuktai technology first appeared in far western Siberia during the height of the LGM. Why this happened is difficult to understand, considering the harshness of the climate, but clearly the people who used it did not move farther eastward across the Kolyma Basin until the end of the glacial period, when environmental conditions made it more feasible to settle the area. It is also possible that they were pushed eastward by early Neolithic peoples who were moving north from central Asia during a warming phase. In any case, there is little doubt that the Late Dyuktai flaking techniques evolved from the microblade techniques developed by earlier Dyuktai flintknappers, as they represent very similar traits. The current archaeological evidence indicates that Late Dyuktai people arrived on the shores of the Bering Sea more than 12,000 years ago. When they finally crossed into the region now known as Alaska, did they find an uninhabited territory, or did they encounter people already living in the area—or even moving westward out of eastern Beringia?

EASTERN BERINGIA

The archaeology of eastern Beringia is also difficult to assess. As in western Beringia, the number of well-dated and stratified sites is meager, but at least two technological patterns are beginning to emerge. The majority of early Alaskan sites, like those in Siberia, seem to have been occupied by people who used microblade technology at about the same time as or shortly after it appeared in northeastern Asia. We suggest this indicates that the microblade-based industry of Siberia spread eastward into Alaska near the end of the Late Dyuktai period. The regional and temporal spread of this microblade technology—and its offshoots—tells us that the people with this technology were well suited to the environment and flourished, developing into distinct groups. However, at about the time when this highly dynamic pan-Siberian technology was becoming established in eastern Beringia, people using non-microblade weaponry were also making an appearance in the area. Where did they come from?

The settlement of Alaska (eastern Beringia) was probably a slow, complex process stimulated by climatic improvement, as the Arctic archaeologist John Hoffecker and his associates suggest.[20] Milder weather conditions and nutrients released from the melting glaciers enhanced the productivity of rangelands. Increased subsistence resources no doubt affected the human fertility rate, causing the population expansion reflected in a major increase in the number of sites and the diversity of technologies at this time. Groups with different lithic traditions—and therefore unique signatures—moved into Beringia from different directions.

The Beringia (sometimes called the American Paleo-Arctic) tradition is, in our opinion, an eastward extension of Late Dyuktai. One of the earliest assemblages of this tradition comes from the Onion Portage Site on the Kobuk River, just upstream from Kotzebue.[21] This is one of the first deeply stratified sites found in Alaska, and it has provided baseline data for the cultural sequence of northwest Alaska. At the bottom of the site was an unconformity, or buried eroded surface, upon which more than a hundred artifacts were found. The group of artifacts has been named the Akmak Complex. (*Complex* is basically synonymous with the term *archaeological culture:* it describes a group of sites that share specific traits, especially those related to tool forms.) This accumulation of cultural debris is thought to have been redeposited from a cache of precores (figure 3.5a–b), wedge-shaped microblade cores (figure 3.5d), and formal tools such as burinated blades, retouched blades (figure 3.5e), blades retouched into scrapers (figure 3.5f), and bifacially edge-retouched knives (figure 3.5c). A radiocarbon assay of a caribou bone associated with the artifacts indicates that the materials were deposited more than 9,500 years ago. Hence the Akmak tools are older, by an unknown time period. This assemblage is very similar to Late Dyuktai.

Another northwestern interior Alaska site, known as Nogahabara 1, has a toolkit of 267 artifacts that appear to have been lost or abandoned between 12,740 and 13,850 years ago. These artifacts were exposed by the wind deflation of a sand dune. The fact that all

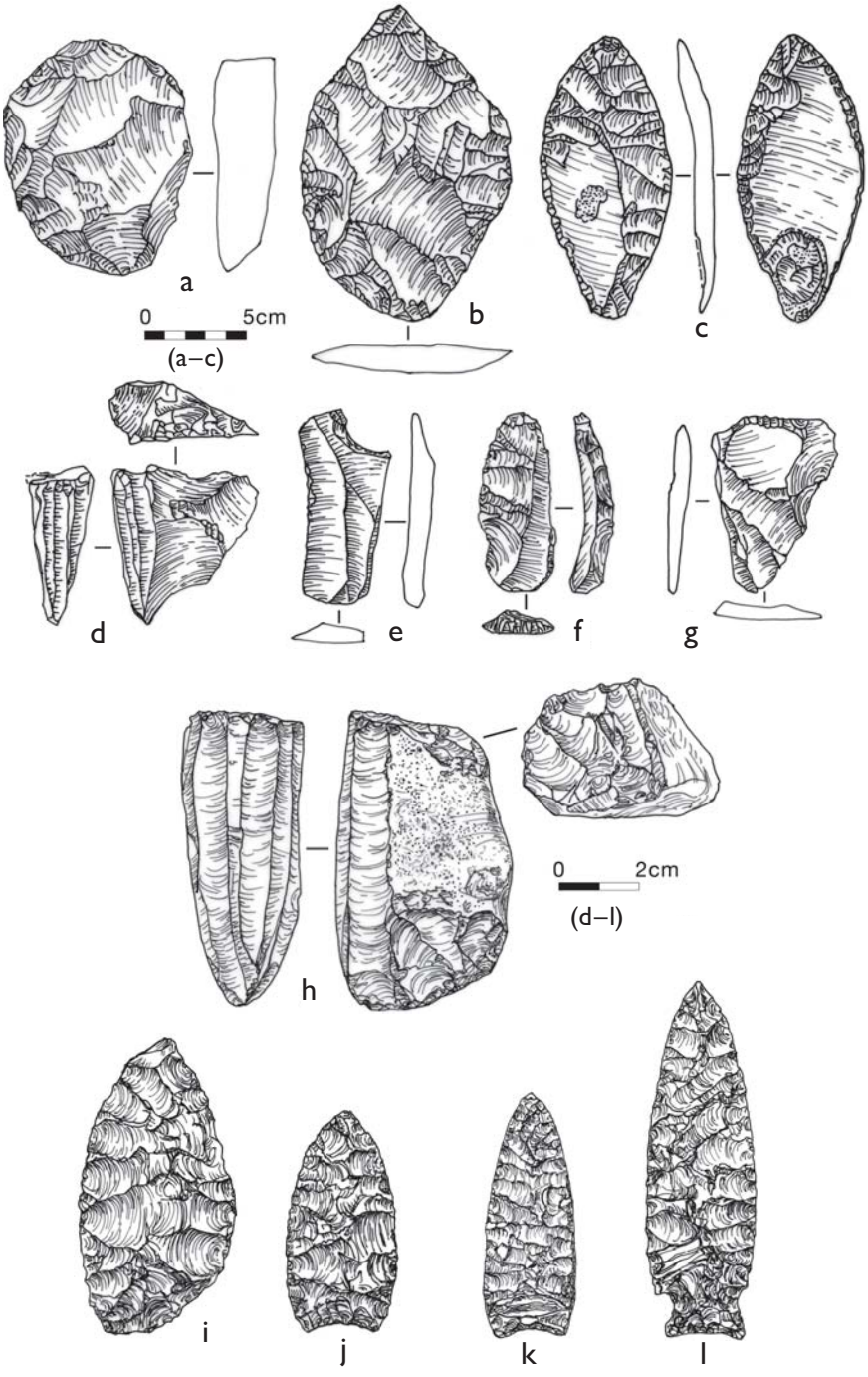


FIGURE 3.5.

Akmak artifacts from Onion Portage (a–f) and Nogahabara 1 artifacts (g–l): (a–b) precores; (c) bifacially edge-retouched knife; (d) wedge-shaped microblade core; (e) retouched blade; (f) blade retouched into scraper; (g) retouched flake; (h) pressure microblade core; (i) projectile point preform; (j–k) lanceolate projectile points (possible preforms for notched points); (l) notched point.

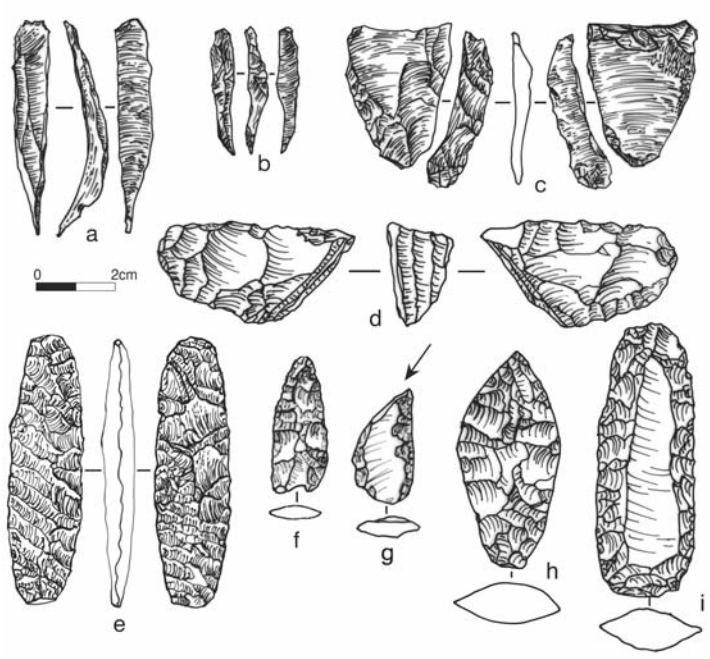


FIGURE 3.6.
Pre-Nenana (a–c) and Denali (d–i) artifacts: (a–b) microblades from Swan Point; (c) burin and burin spall from Swan Point; (d) microblade core; (e–f) bifacial points and (g) burin from Broken Mammoth; (h–i) bifacially retouched point.

of the artifacts were clustered and, with the exception of a single bifacial chert drill, made from the distant Alaskan Batza Tena obsidian source suggests that this is a single assemblage rather than a lag accumulation resulting from, for example, wind deflation of the dune. The assemblage consists of used flakes and flake blanks (figure 3.5g), pressure blades and pressure blade cores (figure 3.5h), notched and indented base lanceolate (leaf-shaped) projectile points or knives in various stages of manufacture (figure 3.5j–l), and unifacial scrapers. Of interest to our discussion is the unambiguous co-association of pressure blade technology with indented base thinned lanceolate bifaces and notched points. While it has been suggested that the notched and the indented base points are two distinct end products of the same manufacturing system, the lack of edge grinding on the concave base bifaces makes it likely that these specimens are late-stage preforms for notched points or reworked pieces, which are also basally thinned.[22]

The lowest level of the Swan Point Site near Delta, Alaska, provided a date of around 14,000 years ago, making it the earliest directly dated microblade occupation in Alaska.[23] It contained microblades (figure 3.6a–b), a core tablet (figure 3.6c), and detritus from their manufacture, burins, cobble tools, and hammerstones but no bifaces or bifacial points. This occupation is unique in central Alaska since it is below Nenana Complex levels (see below). This strongly suggests that microblade technologies arrived in this part of Be-

ringia before Nenana, a presumably non-microblade complex. This is important because it may indicate that the first people in the area were most likely related to the Siberian peoples—whereas if Nenana was first it could have led to the non-microblade technologies seen in Clovis.

The Denali Complex, according to F. H. West, represents the first colonization of eastern Beringia, at about 12,000 years BP, and remained little changed until its disappearance around 8,000 years BP or later.[24] There is little difference between Late Dyuktai and Denali artifacts, and there is general acceptance that they were closely related. Denali sites, which are widespread in Alaska, are dominated by microblade inset technology but also contain a significant component of bifacial knives and points. Microblades were made primarily on wedge-shaped bifacial cores (figure 3.6d), and bifacial points were intentionally thickened and finished with pressure flaking and lower edge grinding (figure 3.6e–f and h). There are also bifacially retouched flakes (3.6i). Pressure flaking techniques range from selective and nonpatterned to serial and diagonal. Burins are common and take a variety of forms (figure 3.6g).

Trail Creek Cave 2 and Lime Hills Cave 1 are Denali sites. Both produced slotted antler points (figure 3.7a–f), which have bases that are beveled for hafting to a spear shaft. It is clear from these specimens that inset projectile point technology accompanied microblade technology. The remarkably preserved perishable tools from Lime Hills Cave 1 included the base of an antler point or knife and most of a slotted antler projectile point (figure 3.7f).[25] The slots run along opposite sides and were designed to hold microblade segments, some of which were found in association. The artifacts from these sites date to about 9,500 years BP.

Several fluted points were found during the 1940s and 1950s along the Utukok River in northern Alaska. Since all of the points were surface finds and not directly datable, archaeologists used the tried and true typological approach to cross-date them. Because they were fluted and looked somewhat like Clovis, they were considered evidence of an Alaskan antecedent to Clovis. The real clincher for the pre-Clovis case was that the Alaskan fluting technique was significantly different from that of Clovis, suggesting that it was an early developmental phase of the technology. And, after all, the points were found where the prevalent origin theory predicted they would be.

This pre-Clovis notion seemed to be confirmed by further work on the North Slope during the 1960s and 1970s. First, Robert Humphrey, while a PhD student at the University of New Mexico, conducted a reinvestigation of the Utukok River area in the hope of finding more diagnostic artifacts in a datable context. He discovered a site that produced additional fluted point fragments, along with evidence of the manufacture of weapon tip replacements.[26] A radiocarbon date of 17,300±800 years BP was obtained from a mammoth bone found eroding out of a nearby bank. Perhaps the date was too old, because it meant a gap of almost 6,000 years between it and Clovis, but nonetheless it was pre-Clovis.

Additional fluted points were recovered a few years later at the Putu Site, on the North Slope of the Brooks Range, and a charcoal date suggested that their age might be 11,470±500

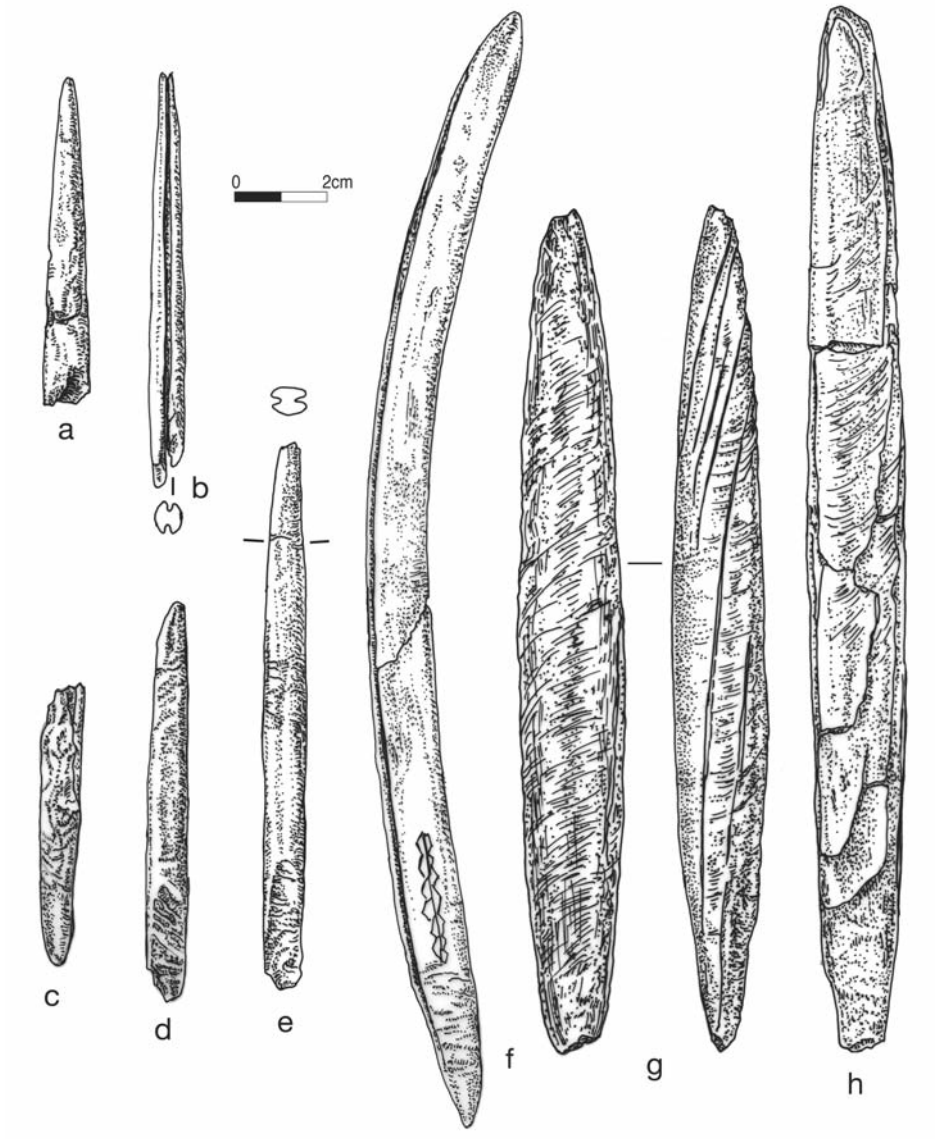


FIGURE 3.7.
Slotted antler points and ivory tools: (a–e) antler points from Trail Creek Cave 2 (cross-section outlines of b and e illustrate grooves for microblade insets); (f) antler points from Lime Hills Cave 1; (g–h) Nenana ivory tools from the Broken Mammoth Site, not slotted for microblade.

RCYBP (radiocarbon years before the present).[27] This date was absolutely perfect, establishing fluted-point makers in the American Arctic at least 200 years before their arrival on the plains. Unfortunately, when the geologists Tom Hamilton and Steve Porter undertook geological studies in the area, they discovered that the location was beneath a glacier until around 13,000–13,500 years ago.[28] According to environmental reconstruc-

NORTH TO ALASKA

In 1966 I accompanied Robert L. Humphrey Jr. in a search for Clovis sites along the Utukok River, where an Alaskan fluted point had been found in 1949. We were fortunate to find a campsite where early people had lived and manufactured fluted points, surely evidence of the first Clovis peoples in northwest Alaska. We were also hoping to find charcoal that would date older than the radiocarbon assays from Clovis sites in the Lower Forty-Eight. Unfortunately, we found no charcoal at our campsite, but instead we dated a sample from a mammoth bone that was eroding out of the adjacent riverbank. The mammoth bone dated to more than 17,000 years old, likely too old to be associated with the fluted point campsite.

I have spent many more field seasons over the past forty years in various parts of Alaska searching for evidence of the peopling of the Americas. It was not until the summer of 2005 that Bob Gal, National Park Service archaeologist for northwest Alaska, found the first fluted point site in Alaska with associated charcoal. The assay of the charcoal suggested that the descendants of Clovis people started living in Alaska no more than 12,000 years ago . . . long after mammoth hunters camped at the springs of Blackwater Draw. *Dennis*

tions, the site would have been, at the very best, part of an unattractive, barren pile of rocks until long after Clovis times. To clarify this situation, Mike Kuntz and Rick Reanier conducted new excavations, which confirmed a younger date for the fluted points.[29]

Although more fluted points have been found on the surface at several locations in the Brooks Range, none has been in a good geological context. Since these finds, geological mapping and controlled excavations have demonstrated that the Alaskan fluted point complex is younger than Clovis rather than being a Clovis ancestor. In fact, some archaeologists have argued that these points represent an intrusion of late Clovis people into the Arctic, or at least a northward diffusion of the post-Clovis mid-continental fluting technology.[30] Current excavations at the Serpentine Hot Springs Site in western Alaska, where fluted points have been found in good context, have yielded radiocarbon dates of around 12,000 years ago.[31] Support for the idea also comes from the ice-free corridor in Canada.

The plains of Alberta and areas northward toward the ice-free corridor have yielded fluted points.[32] Like the Alaskan specimens, most of these artifacts are neither well fluted nor representative of classic Clovis technology. This situation can be interpreted in two ways. One is that the artifacts represent early Clovis technology evolving as people moved southward. Conversely, they might represent a post-Clovis fluting strategy that was spreading northward. It would be great if the former could be proved, but there are several arguments against a pre-Clovis antiquity of the Canadian specimens.

Also like the Alaska specimens, the Canadian points are surface finds without good contextual data—with one exception. A single fluted weapon tip was recovered from a stratified site known as Charlie Lake Cave, on the very western edge of the ice-free corridor in British Columbia.[33] A radiocarbon assay yielded a date of 12,000 years ago for the fluted point level. This date fits the new deglaciation chronology reasonably well and is consistent with the information coming out of Alaska. Furthermore, the dating of fossil remains from the ice-free corridor suggests that animals were not living in the corridor before 13,000 years ago. At present the Charlie Lake Cave radiocarbon date, along with the younger age estimates for the Alaskan specimens, supports the existence of a post-Clovis technological link between the Northern Plains and the Arctic. In addition, the technology of these Canadian points is more like that of some of the post-Clovis fluted points found in the northeastern and upper midwestern United States and eastern Canada. Perhaps all of these types represent Clovis-derived people who followed the retreating ice front northward through the opening corridor into Alaska.

The lanceolate projectile points found at the Mesa Site suggest the possibility of a second technological intrusion into northern Alaska.[34] Although similar projectile points are known from surface collections, Mesa is the first site where they are found in a reasonable stratigraphic context and dated by charcoal from associated hearths. The Mesa Site, like the Putu Site, is on the North Slope of the Brooks Range, just ninety miles, not far in Alaskan terms, from the location of the first fluted point finds. The site sits atop a prominent flat-top landform (hence its name) and overlooks the wide expanse of the North Slope in all directions.

Numerous fire hearths at Mesa provided charcoal, whose radiocarbon dates range from about 14,000 to 12,000 years ago. If the outlier assays are eliminated, there is a strong cluster of dates between 9,900 and 10,200 years RCYBP. The 7,600 years RCYBP date may have been a laboratory error, and redating the same sample placed the hearth in the 10,000 years BP cluster. Mike Kuntz and Rick Reanier, the principle investigators of the site, suggest that the oldest dates represent an earlier occupation by the same group, but the evidence for this is not compelling.[35] In a review of early Alaskan archaeological data, Tom Hamilton and Ted Goebel mention the possibility that 1,400-year-old wood was used for fuel in the single earlier-dated hearth.[36] This explanation is reasonable because ancient wood is widely preserved in permafrost and commonly found in exposed cut banks and river gravels. These windfall gifts are collected and burned in many parts of northern Alaska, where combustible materials are in short supply.

Artifacts from the Mesa Site include flake tools, small end scrapers and gravers, large bifaces, and lanceolate projectile points (figure 3.8a–c). There is also a massive collection of waste flakes from tool manufacture and resharpening. In broad outline, the Mesa Site projectile points are similar to Agate Basin Paleo-Indian weapon tips found on the High Plains and Rocky Mountain areas of the mid-continent.[37] However, Agate Basin sites date slightly older than the Mesa Site. Moreover, there is a major technological difference. Mesa projectile points are thick relative to their width, a trait they share with other Beringian points.

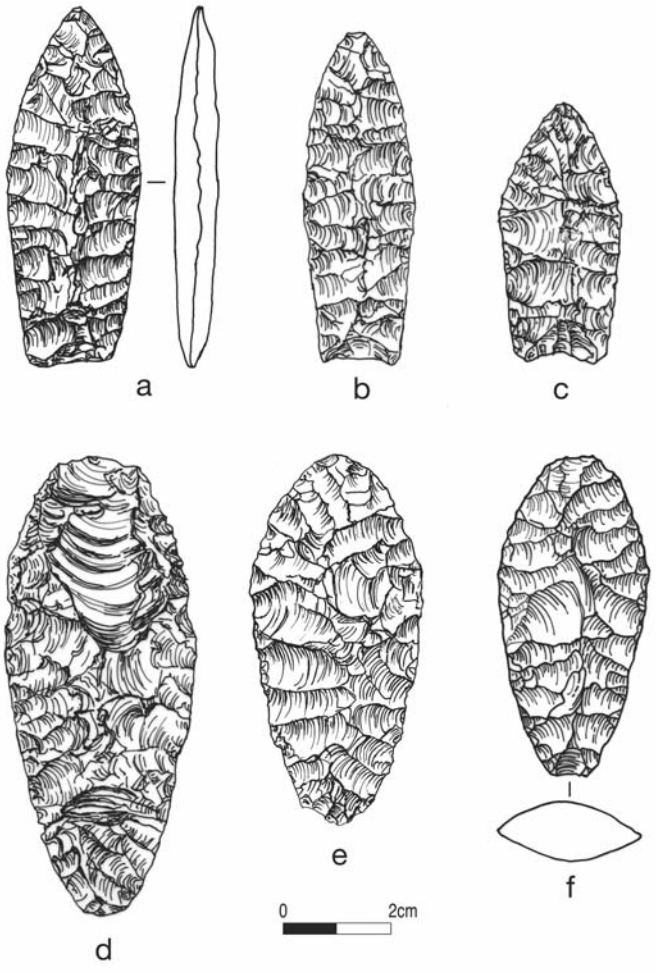


FIGURE 3.8.
Projectile points: (a–c) Mesa Site; (d–f) Sluiceway Site.

Agate Basin technology, by contrast, strove for weapon tips that were longer, thinner, and flat. A better analogy for the Mesa points is the Intermountain lanceolate point types found in the western Rockies and northern Plateau.[38] These weapon tips, like the Mesa ones, have thickened cross sections, slightly indented bases, and ground lower edges.

One plausible interpretation is that the Mesa Site represents a hunting overlook occupied by a Paleo-Indian group whose origin was the Plateau or the Rocky Mountains of North America. If this interpretation is correct, at least two of the earliest archaeological cultures in eastern Beringia originated not from western Beringia in eastern Asia but from North America to the southeast. This is compatible with research indicating that the ice-free corridor was not a viable option for human habitation until around 13,000 years ago, or about the time when Paleo-Indian sites appear in eastern Beringia. Also, when the cor-

ridor finally opened, it did so from the south, providing ever-increasing opportunities for people and animals living in the mid-latitude areas to move northward.

Another group of sites just to the west of Mesa produced lanceolate projectile points that are also not associated with microblades. Known as Sluiceway points, they are between 12,000 and 13,000 years old.[39] These weapon tips are much more robust than the Mesa points, but like Mesa points they are very thick relative to their width. They are bipointed, finished by pressure flaking, and basally ground (figure 3.8d–f). Several of the Sluiceway sites are game overlooks, where weaponry was replaced and repaired, and one is at a chert source, where new projectile point stock was manufactured.

The Mesa and Sluiceway overlook sites were likely locations of male-dominated activities; campsites that would tell us about group composition and yield tools from the activities of both genders have not been found. If the radiocarbon dates are correct, Sluiceway is slightly older than and may represent a precursor of the Mesa technology, making it unnecessary to search for a plains antecedent for Mesa. If one wants to see their origins as Asian, an argument could be made that the absence of microblades simply reflects the fact that Sluiceway and Mesa are task-specific sites, and both of these groups might have used antler points inset with microblades while hunting different prey or at different times of the year.[40] However, we see this as unlikely, as microblades have only occurred with Sluiceway points in surface assemblages.

Are there any other possibilities for the origins of Clovis technology in eastern Beringia? An intriguing group of sites in central Alaska, along the Tanana and Nenana Rivers and their tributaries, has drawn the attention of archaeologists searching for Clovis origins. However, there are some critical problems with this interpretation, not the least being that these sites are contemporary with or younger than Clovis. Hence some investigators, including Thomas Hamilton and Ted Goebel, have hypothesized that Clovis and Nenana are historically related through a common, as yet unidentified, ancestor.[41] We think they may be correct but look to the southeast, to assemblages that predate Clovis, such as the Miller Complex in Pennsylvania, as probably ancestral, rather than to eastern Asia.

Nenana sites are located on the tops of alluvial terraces in wind-deposited sediments. A few of them are stratified, with cultural levels in good unmixed contexts. They have yielded some of the earliest dates in eastern Beringia, although as usual there is a wide range of dates. Hamilton and Goebel dismiss the earliest dates and place the Nenana Complex around 13,000 years old.

Artifacts from Nenana Complex sites consist of bifacial waste flakes, bifacially retouched tools (figure 3.9a), end scrapers (figure 3.9b), gravers (figure 3.9c), side scrapers (figure 3.9d), retouched flakes (figure 3.9e), ovoid bifaces (figure 3.9f), triangular points (figure 3.9g), and retouched bladelike flakes (figure 3.9h). These small bifaces, known as Chindadn points, are slightly retouched thin flakes that have been interpreted as small hafted knives rather than points.[42] No large blades, blade cores, or blade-manufacturing debris have been found to verify the existence of a Nenana large-blade technology.

The few Nenana bone and ivory tools include possible ivory points without basal bevels

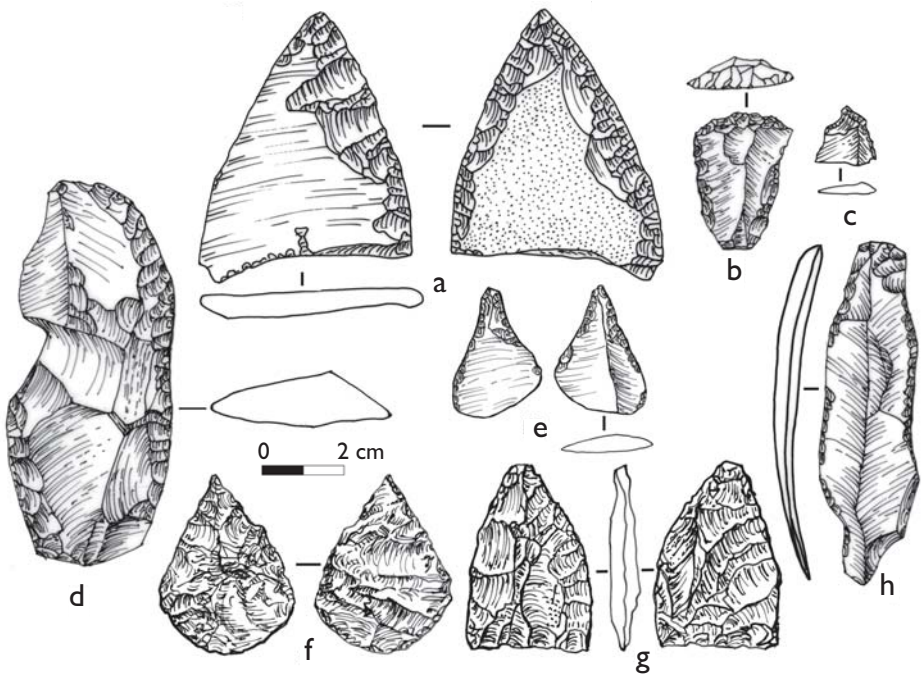


FIGURE 3.9.
Nenana artifacts: (a) bifacially retouched tool; (b) end scraper; (c) graver; (d) side scraper; (e) retouched flake; (f) ovoid biface (Chindadn point); (g) triangular bifacial point; (h) retouched bladelike flake.

(figure 3.7g–h), an eyed bone needle, and three poorly preserved mammoth ivory rods that date to around 10,300 years BP. One of these rods is bipointed, and the other two are not complete enough to assess their original forms. None of them has a beveled base like the Clovis rods. Although no formal bone tools were found in the Nenana occupation levels at the Swan Point Site, several pieces of worked mammoth tusk were recovered among the associated faunal remains.

A clue about Nenana technology is found at Broken Mammoth, where along with the remains of a few medium-sized ungulates, there are a considerable number of migratory waterfowl bones, suggesting a summer occupation.[43] If trapping and netting were the main techniques used to procure these resources, that would explain the absence of large stone projectile points or even slotted bone points. At another site or in a different season, the same people who used these tools may well have used other weaponry systems. For instance, we know that microblades at Trail Creek Cave were fitted into slotted antler projectile points, and later Arctic peoples used similar but unslotted projectile points for hunting caribou. However, since caribou migrate out of central Alaska during the summer, such projectile points are not used at and generally do not appear in the debris of campsites oriented to other economic endeavors such as plant collection and processing and fishing. After additional work at Swan Point, Barbara Crass and Charles Holmes pre-

sented a paper indicating that Nenana is clearly related to the Late Dyuktai microblade tradition.[44]

Overall, the archaeological record of eastern Beringia holds together well as representing the wide-ranging continuation of a slow eastward expansion of a generalized, Arctic-adapted Upper Paleolithic microblade tradition. The derivation of the Denali Complex from the western Beringian Dyuktai is evident. This does not, however, explain all of the early assemblages in eastern Beringia. The interesting obstacle to the seemingly straightforward single-Asian-origin explanation is the probability that the early fluted point technology of the northern slope of the Brooks Range ultimately derives from the Paleo-Indian traditions of the subglacial portions of North America, specifically the High Plains and Rocky Mountain regions. There is also the possibility that the Sluiceway-Mesa Complex had its origins in the south as well. The absence of an early microblade tradition in the ice-free corridor east of the northern Rockies, in spite of the apparent use of this corridor for the introduction of southern elements into the north, further erodes the likelihood of the greater Beringian microblade technology being the historical ancestor of Clovis.

After decades of research, there are still no well-documented sites that provide evidence that people moved into northeastern Siberia or Alaska much before 12,000 years ago. Moreover, the technologies that were carried from Asia to America were almost exclusively microblade based, with only a minor emphasis on bifacial flaking. Large blade sites are not documented in northeastern Siberia and eastern Beringia until very late after Clovis, with the earliest evidence of their use appearing in the Aleutian Islands around 11,000 years ago.

The Beringian archaeological record is lacking in the thinned bifacial technology accompanied by large blade manufacturing we see in Clovis. Combined with the fact that humans did not colonize eastern Beringia until the climate became more hospitable, after the ice age ended around 12,000 years ago, Beringian hunters cannot be ancestors of Clovis peoples. In fact, just the reverse might prove to be the answer to the question of the peopling of the American Arctic.

4

CHALLENGING THE CLOVIS FIRST MODEL

The Missing Links

> By the cautious archaeologist all evidences of ancient man in eastern North America—exclusive of true palaeolithic implements—are wisely referred to those Indian tribes that, to within a comparatively recent period, were the sole occupants of the territory named. Perhaps, however, the time has come when it may be asked if all the traces of prehistoric man, gathered along our northern Atlantic seaboard, are of one origin. In other words, have traces of a people later than American palaeolithic man, and earlier than the Indian, been discovered?
>
> CHARLES C. ABBOTT, "TRACES OF A PRE-INDIAN PEOPLE," 1889

Complex cultures such as Clovis do not spring out of thin air. Whenever and wherever people move, they take with them their language, belief and kinship systems, lifestyle, and traditions. Aspects of cultures change through time when people are faced with new or diminished resources, and this is especially true of material cultures. People adapt to changing environments by finding new ways to deal with habitat shifts. This often requires only adjustments to existing technologies, but in more severe cases it may provoke the development of new ones.[1] Even then, the new technologies are usually based on the older systems, which are modified by trial and error until they prove effective for coping with new circumstances.[2] Alternately, rather than staying in a known territory and adjusting to changes, some groups move along with habitat shifts in order to maintain their traditional lifestyle.

Changes in technology can also result from social stress, usually in the form of internal population growth or decline or, more commonly, the intrusion of alien groups. The last case can result in the wholesale adoption of alien technology or, more likely, a blend of new and old technologies. It is unclear what mechanisms were operating in the development of Clovis, but some permutation of these factors is likely. Clovis could not have been first; it had to develop out of a previous archaeological culture . . . a missing link.

Clovis was well established in North America by at least 13,000 years ago. Hence, to identify possible ancestors, we need to look at assemblages that date to an earlier period. Little data has emerged in either Beringia or northwestern North American to clarify

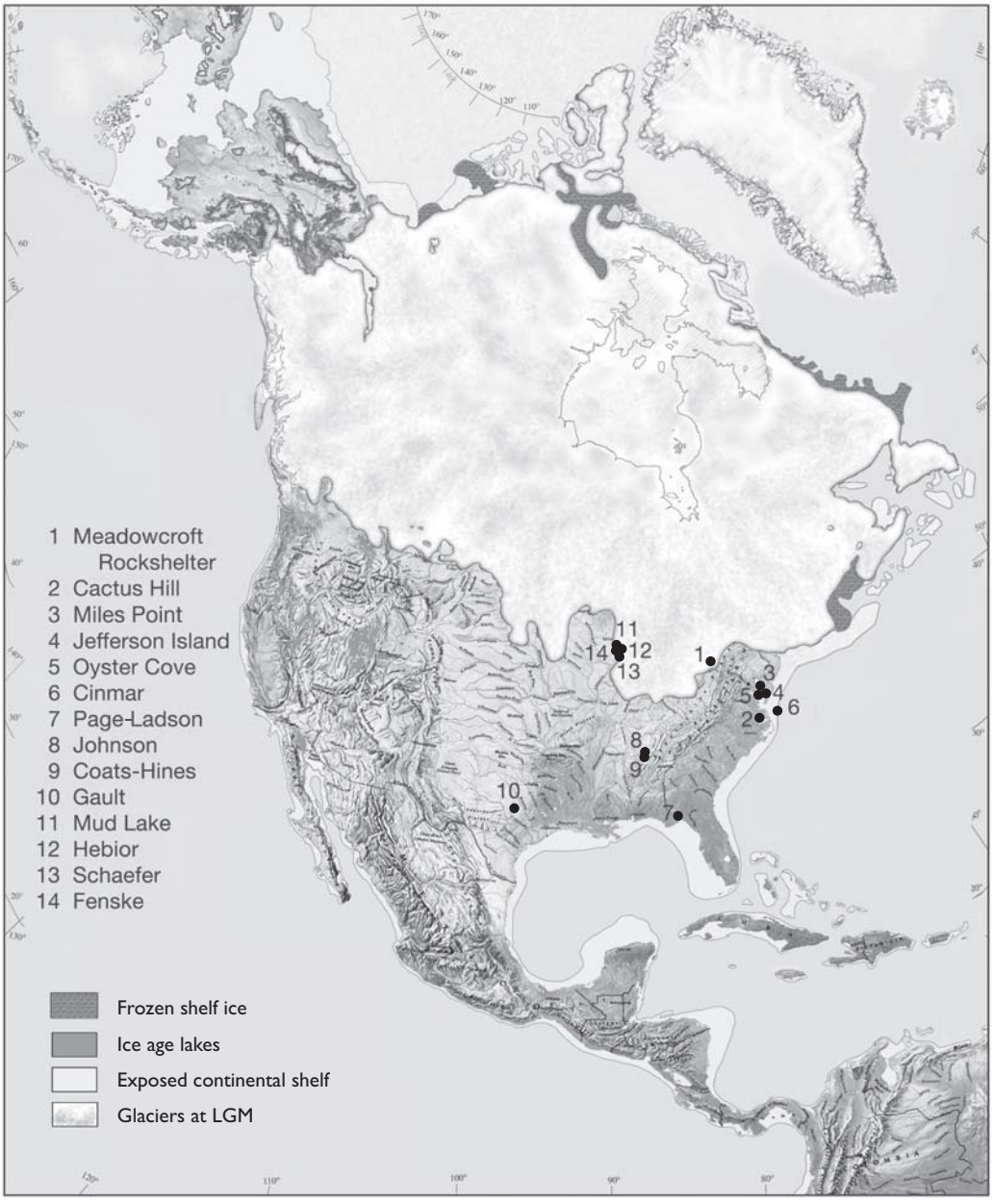


FIGURE 4.1.

North America during the LGM showing the extent of glaciers, exposed continental shelf, and locations of early Paleo-American sites.

Clovis origins.[3] This suggests that scholars are looking in the wrong area of the world for Clovis ancestors. In chapter 2 we hypothesized that Clovis technology as we know it originated along and expanded out of the eastern seaboard, eventually spreading westward through exploration and adaptation. This scenario requires evidence that archaeological cultures with biface-thinning and blade-making technologies that would have been precursors to Clovis technology once flourished along the ice age Atlantic coast and the now submerged continental shelf.

During the last ice age the western Atlantic shelf was a vast and environmentally rich plain stretching from the Grand Banks off Newfoundland to Florida and around the Gulf of Mexico. Most of this region is now submerged under the sea and difficult to access, leading to a paucity of data on early Paleo-American sites that are likely antecedent to Clovis. There are, however, several inland sites that we accept as evidence of a Mid-Atlantic Early Paleo-American occupation (figure 4.1). These include the well-known Meadowcroft Rockshelter, in southwestern Pennsylvania, and Cactus Hill, in southeastern Virginia. Both sites have occupation levels that are earlier than Clovis (confirmed by radiocarbon assays of charcoal recovered from these levels), and their artifact assemblages do contain biface thinning and blade technologies. Miles Point, Cinmar, and Oyster Cove, sites recently discovered on the Chesapeake Bay, provide important data relative to the timing of the early Mid-Atlantic occupations of North America.

Below, we also compare new finds from Jefferson Island on the Chesapeake Bay to finds from the Page-Ladson Site in Florida, and examine the Johnson and Coats-Hines sites in Tennessee for evidence of technological transitions from the earlier Mid-Atlantic Paleo-Indian assemblages into Proto-Clovis technologies. We do not exclude the possibility that other earlier cultures existed elsewhere in the Americas, but their examination is not relevant for evaluating our hypothesis on the origins of Clovis.[4]

THE MID-ATLANTIC EVIDENCE

Meadowcroft Rockshelter is on the Appalachian Plateau some 50 kilometers southwest of Pittsburgh, Pennsylvania. At 80 meters above sea level, the shelter faces south and overlooks Cross Creek, a small tributary of the Ohio River. Although the Laurentide Glacier approached within 84 kilometers of Meadowcroft at its maximum, by the time of human occupation of the shelter, it had retreated some 223 kilometers to the north.

The eleven distinct geological strata identified in the 4-meter accumulation here provide a nearly complete sequence of the known archaeological cultures in southwestern Pennsylvania. Stratum IIa was isolated from those above and below by episodes of rocks falling from the ceiling and contained at least fourteen hearths that range in age from 11,300 to 16,175 radiocarbon years before the present (13,200 to 19,200 years ago; see the introduction for information on radiocarbon dating). It also had two main occupation levels with concentrations of flaked stone artifacts and faunal remains. The younger con-

centration dated to between 11,300 and 12,800 RCYBP (13,200 to 15,100 years ago), the older to between 15,000 and 16,000 RCYBP (18,300 to 19,200 years ago).

Stratum IIa contained animal bones, wood fragments, mollusk shells, cordage, several small bladelets, several hundred waste flakes, and retouched flakes and bladelets (figure 4.2b–d). There is a single bifacial projectile point from stratum IIa that has convex sides and a more or less straight base (figure 4.2a). It exhibits percussion and pressure flake scars. It is neither thick nor thin and may be considered proportional (see chapter 1 for a discussion of these terms). An impact flake scar on the tip indicates that the point broke after striking a resistant object and was subsequently repaired. Thus, its present shape and proportions do not represent its original configuration. James Adovasio, the archaeologist who investigated the site, named the projectile point Miller and the occupation assemblage the Miller Complex.[5]

Although most of the raw materials used by the Meadowcroft flintknappers were of local origin, exceptions include Flint Ridge chert from eastern Ohio, Kanawha chert from West Virginia, and Onondaga chert from New York. Whether these stones were collected by Meadowcroft flintknappers or obtained by trade is unknown. In either case, however, their presence implies a deep knowledge of a large geographic region, which is not characteristic of a pioneering population.

Virtually everyone accepts the stratigraphic context of these assemblages. In fact, the excavations conducted by Adovasio and his associates have been judged absolutely meticulous.[6] We agree that Meadowcroft may have been occupied as early as 19,200 years ago, and was clearly occupied by around 14,600 years ago by people whose biface and blade technology could be ancestral to Clovis.

Along with the excavation of the rockshelter, the Meadowcroft project included a survey of the adjacent Cross Creek drainage system, where investigators located a site now known as Krajacic. Here they found a concentration of artifacts on or just below the ground surface that included projectile points reminiscent of the one from stratum IIa at Meadowcroft (figure 4.2e–f), as well as polyhedral/conical bladelet cores (figure 4.2g).[7] Although the Krajacic artifacts are undated and possibly from a mixed context, their technological similarity to those from Meadowcroft and the method of the manufacture of the bladelets encouraged Adovasio to conclude that they are part of the Miller Complex.

Adovasio points out that the bladelet cores from the Cross Creek drainage are reminiscent of cores from northern China that are around 30,000 years old. He speculates that this Asian technology might have been a prototype that spread into North America during the Last Glacial Maximum and eventually gave rise to the Miller Complex. If this speculation is correct, there should be sites containing the proto-technology that become progressively younger as they approach Meadowcroft along the 10,000-or-so-mile trail. So far none have been discovered.

The final verdict on the earliest cultural levels at Meadowcroft remains disputed, and many critics have required (perhaps unreasonably) that other sites with Miller Complex artifacts and equally early radiocarbon assays be found before they accept the early dates

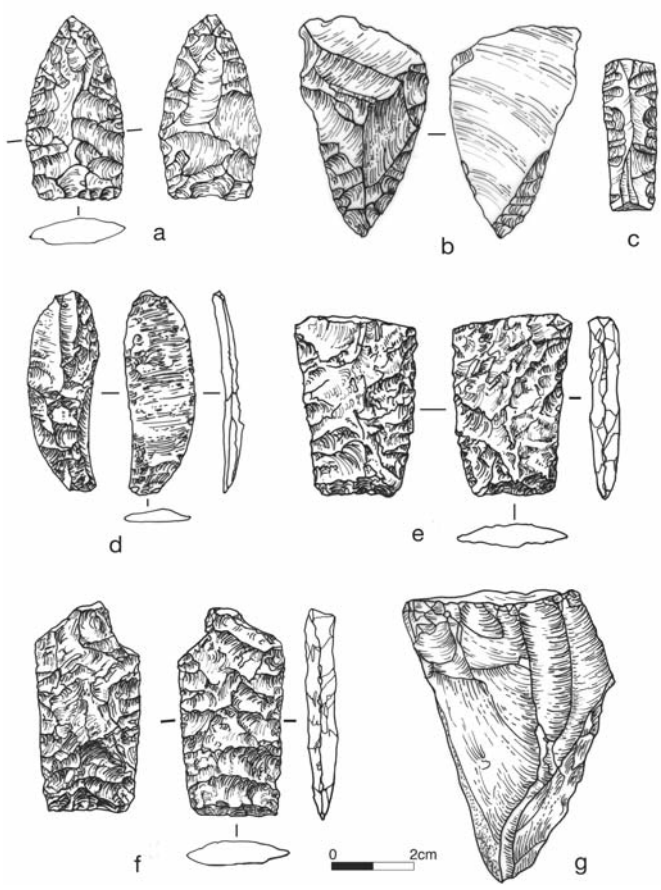


FIGURE 4.2.
Meadowcroft (a–d) and Krajacic (e–g) artifacts from the Miller Complex: (a) obverse, reverse, and cross section of projectile point; (b) obverse and reverse sides of retouched flake tool; (c) retouched bladelet; (d) obverse, reverse, and side view of bladelet; (e–f) obverse, reverse, and side view of biface fragments; (g) bladelet core.

at Meadowcroft.[8] In our opinion the demand for a second site to validate the antiquity of the Miller Complex was satisfied by the discovery of similar artifacts at the Cactus Hill Site in southeastern Virginia. This site contains a relatively unmixed stratigraphic sequence of Mid-Atlantic cultures from circa 22,000 years ago to historic times in the seventeenth century. Of particular interest are the earliest levels, which are situated below the Clovis occupation level.

Two research teams have investigated this location. Joe McAvoy and his team from the Nottoway River Survey excavated several areas, and Mike Johnson and volunteers from the Archaeological Society of Virginia excavated other parts of the site. McAvoy's detailed report of the ongoing interdisciplinary investigations is the basis for our inferences about the significance of Cactus Hill.[9]

Cactus Hill is on the east bank of the Nottoway River in Sussex County, Virginia, some 13 miles east of the Fall Zone, a limestone escarpment that defines the eastern edge of the Virginia Piedmont. During the early occupation of the site, the river meandered its way across 180 miles of the Atlantic Coastal Plain until it drained into Albemarle Sound on the ice age coast of North Carolina. A series of prehistoric campsites were situated on an east-west-trending sandy ridge deposited on the first terrace of the river at roughly 80 feet above sea level.

The ridge was formed by wind-blown sand from riverine deposits and by sediments deposited during the flooding of a backwater channel adjacent to the site. A flood-scoured wetland basin south and west of the sand ridge was a source of water and a diverse array of game animals and edible plants, seeds, and fruits. Quartzite cobbles deposited along the banks of the Nottoway and alluvial point bars provided an ample source of stone raw material, which enhanced the lure of this well-situated campsite.

Sand began to accumulate on the terrace around 22,600 years ago, and the dune underwent a series of building, stable, and deflationary phases, reflecting periodic local and regional environmental perturbations. Plant life was established and soils developed when the dune was stable, whereas drier and windy conditions caused deflation. Sometime between 20,100 and 22,600 years ago, people began to use the sand ridge as a temporary campsite. The sand apparently ceased to accumulate either during or just after the earliest occupations, creating a stable surface that allowed soil to develop. Later there was a new round of dune building and subsequent deflation. The deflation removed the upper part of the buried soil, leaving only slight traces of its former existence. Eventually, sand once again began to build up over the crest of the dune. How much sand may have accumulated during this episode is unknown, but when Clovis hunters established a camp on the ridge about 12,900 years ago, only three to six inches of sand separated their living floor from the earlier occupation some 7,000–8,000 years older. However, faint traces of the former soil were identified between the two occupation zones, clearly indicating that the two occupation levels represented separate and independent camping events. After Clovis times there was a relatively constant accretion of sand until the modern ground surface was established.[10]

Since depositional and preservation conditions eliminated obvious stratigraphic boundaries and only a thin layer of sand separates the Clovis and underlying artifacts, it may be that a natural process, through which animals, plants, or even people churned up the sand, caused some of the Clovis artifacts to work their way down into a lower stratum and thus gave a faulty indication of very early Clovis-like materials. If this were true, however, one would expect the stone materials in the lower levels to include the types used in the upper levels, and this is not the case. The flintknappers of the early occupation primarily flaked the local quartzite, whereas the Clovis craftsmen worked a wide variety of cherts, jaspers, and other more exotic stones. Hence, we agree with the site investigators that trickle-down redeposition was not a significant factor and that the occupation levels are not mixed.

Of major importance are two areas where charcoal concentrations indicated possible hearth features. The youngest, represented by a scatter of white pine charcoal, produced a date of 15,070±70 RCYBP (18,450 years ago). Seven quartzite flakes and three blades were found associated with this charcoal scatter. A second hearth-like feature somewhat deeper than the first was dated to 16,670±730 RCYBP (19,800 years ago). Another dating method, called Optically Stimulated Luminescence (OSL), produced similar results supporting the accuracy of the original dates.

Burned phytoliths (silicate particles formed in plant cells) were found in these features and are not part of the general background noise in the sediments.[11] Their presence favors the identification as fire hearths rather than simply scatters of charcoal flecks. Additionally, geochemical tests revealed high traces of phosphorus in the strata where the artifact clusters were found, while phosphorus traces were low in the non-cultural strata. The high phosphorus levels are attributable to concentrated biological refuse resulting from human activities. All of these tests support the integrity of the site.

Three distinct artifact clusters were also encountered, two associated with the hearths. The upper cluster contained two bifacial projectiles (figure 4.3a–b), a retouched biface flake (figure 4.3c), and five small bladelets averaging 29 millimeters long, 16 wide, and 3.6 thick (figure 4.3d–e). The middle cluster consisted of two concentrations of nine quartzite blades (figure 4.3f) associated with the 18,000-year-old hearth feature. These blades are larger than those from the upper cluster, averaging 66 millimeters long, 28 wide, and 7.8 thick. The third cluster contained six incomplete blades or broken tools made on blades. These overlap the range of sizes of Clovis blades, but they tend to be shorter while maintaining the width-thickness dimensions of Clovis blades.[12] There is also a scraper plane (figure 4.3g) and a flake core (4.3h).

As in stratum IIa at Meadowcroft, the artifact assemblage from these lowest levels at Cactus Hill is sparse. The waste flakes and most of the blades and unifacial tools are made almost exclusively from the local quartzite, whereas the two projectile points are made from a metavolcanic rhyolite from a more distant source.

Mike Johnson independently conducted research in another locality at the Cactus Hill Site.[13] While working there he became familiar with the various quartzites present in the gravels of the nearby Nottoway River. These were the same materials used by the earliest inhabitants of the Cactus Hill Site. Being curious about the flaking qualities of this material and an accomplished knapper, he focused on learning all he could about how this quartzite flakes and especially if it has any apparent limitations. While at first glance it looks coarse, tough, and intractable, with proper flaking techniques and tools it can be a reasonable material. This is attested to by the large number of well-made quartzite projectile points and knives from various time periods in the area.

On the other hand, these quartzites pose some interesting challenges to a knapper. They are limited in size, with those 15 by 10 by 5 centimeters being at the large end. The exterior surfaces are water worn and smooth. The shapes are uniformly rounded ovoids. These characteristics make the cobbles difficult to break into. Once knapping starts, flakes

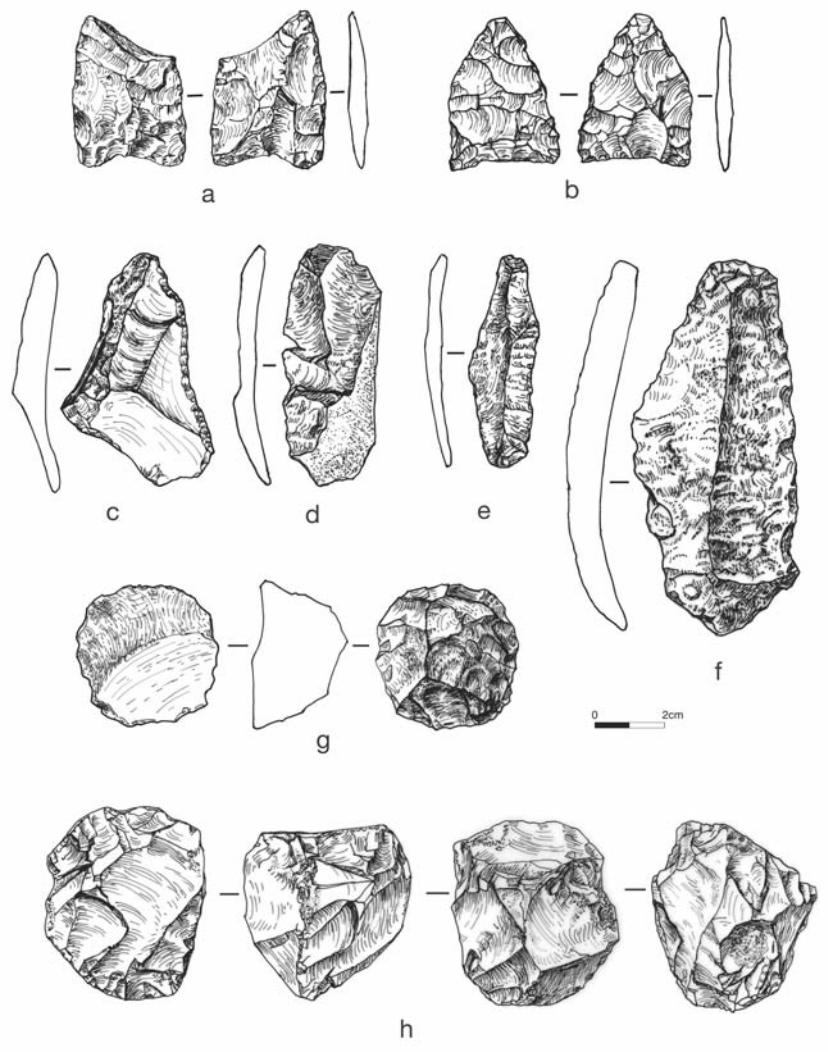


FIGURE 4.3.
Cactus Hill artifacts: (a–b) obverse, reverse, and sections of projectile points; (c) retouched flake; (d–e) bladelets, (f) blade; (g) scraper plane; (h) flake core.

tend to break off with step terminations, especially as they get thinner. The stone is coarse and hard but also quite brittle. Johnson has developed a low-energy antler flaking technique that seems to work best, showing that this material may be flaked in a controlled manner.

These quartzites can be used to make decent bifacial tools like knives and projectile points, but it might be difficult to use the cobbles for the production of large blades. It is, however, quite easy to produce smaller bladelets from the quartzites. Even if the Cactus Hill flintknappers were accustomed to making large blades, it is unlikely that they would

have made them from the local quartzite. The difficulties of flaking these materials may be the reason that a large blade technology is not present at Cactus Hill. Significantly, the same sorts of quartzites are the main raw material available across much of the Vasco-Cantabrian region of northern Spain, where large blade technology is also rare. The large blades and cores found in that region were made from non-local cherts and flints.

The Cactus Hill projectile points are small, sub-triangular lanceolate bifaces with slightly indented bases. They are relatively thin and have slight to no basal grinding. Although McAvoy describes the point technology as being highly controlled percussion, based on our knapping experience, we consider much of the final flaking to be selective pressure. It is probable, as McAvoy suggests, that these points have been reworked from larger broken lanceolate weapon tips, much like the Miller point from Meadowcroft.

If Meadowcroft and Cactus Hill are not proof enough of a pre-Clovis occupation of eastern North America, a site found actively eroding from pre-Clovis deposits should clinch the argument. Darrin Lowery, while a graduate student in the Department of Geography at the University of Delaware, discovered Miles Point while surveying for archaeological evidence along the Eastern Shore of the Chesapeake Bay.[14] At the time of occupation the site was on the Miles River, a second order tributary of the Susquehanna, but today the intersection of these rivers is submerged under Chesapeake Bay. The presence of several freshwater springs at the site likely attracted early hunters to the locality.

Lowery recognized the significance of a large quartzite boulder protruding from an LGM loess (wind-lain sediment derived from glacial deposits) exposed in a wave-cut vertical bank. He and the geologist Dan Wagner cleaned the boulder's profile to assess its depositional situation. Their efforts were rewarded by the discovery that the boulder was not only *in situ,* in its original undisturbed position, but had been used by a flintknapper as an anvil. The boulder had impact depression scars on its upper surface, and two quartzite bladelets (figure 4.4a–b), an exhausted bi-polar bladelet core (figure 4.4c), and a hammerstone were arrayed around it. A projectile point (figure 4.4d), a biface preform (figure 4.4e), a burinated biface fragment (figure 4.4f), another quartzite blade and several retouched flake tools (figure 4.4g), a polyhedral bladelet core (figure 4.4h), a decortication flake (figure 4.4i), and a flake core (figure 4.4j) were recovered during subsequent trips to the site for mapping and collecting soil and dating samples.

The artifacts are made of raw materials that are locally available in exposed gravel deposits. The cherts found in these gravel deposits were washed downriver from bedrock sources in Pennsylvania, but unfortunately as they tumbled downstream they were battered into fist-sized cobbles, limiting the potential size of the artifacts to be manufactured. Early flintknappers would likely have explored upriver to seek larger cobbles, perhaps ultimately discovering their bedrock sources. Such expeditions up the Susquehanna would have taken the paleo-explorers into Pennsylvania and New York. Perhaps they even carried cherts from newly found sources to Meadowcroft Rockshelter.

The occupation level at Miles Point is about 10 centimeters below a paleosol (an ancient soil) that developed in the LGM loess (figure 4.5). The soil, tentatively termed the

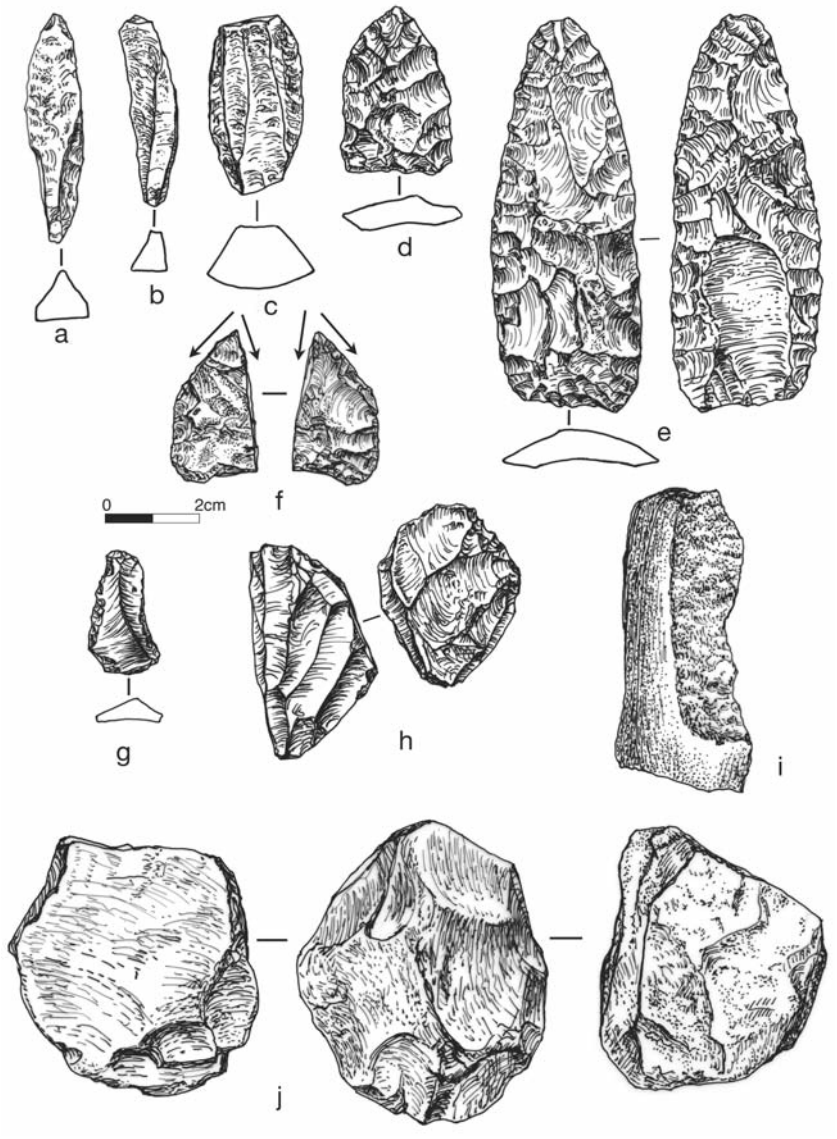


FIGURE 4.4.
Miles Point artifacts: (a–b) bi-polar blades; (c) bi-polar core; (d) projectile point; (e) biface preform; (f) biface fragment used as a burin, with arrows indicating multiple burin spall removals; (g) retouched flake tool; (h) polyhedral bladelet core; (i) decortication flake; (j) large polyhedral flake core.

Tilghman Paleosol, is a horizon marker—a distinctive deposit found over a wide area that can be recognized as a stratigraphic horizon having a single geological source—with calibrated radiocarbon dates ranging between 16,300 and greater than 24,000 years old at four localities throughout the region.[15] It may be equivalent to a climatic warming phase known as the Alerød/Bølling interstadial in Europe. It was during this climatic episode

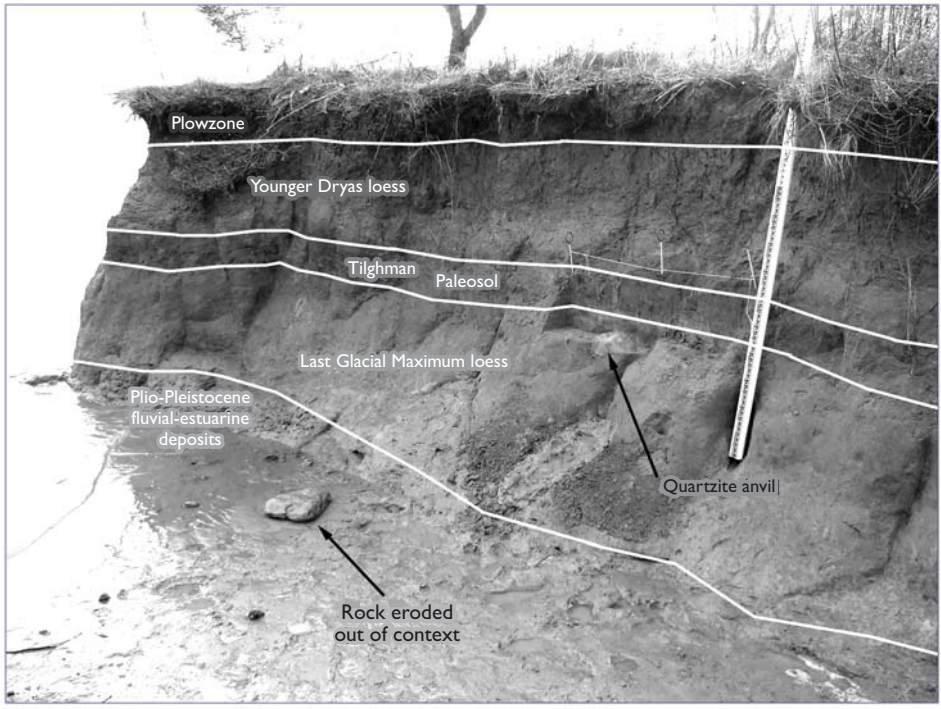


FIGURE 4.5.
Miles Point stratigraphy showing in situ quartzite anvil. (Photo by Darrin Lowery)

that the productivity of grasses and other plants increased, causing soils to become highly organic and readily recognizable by their dark color. This warming phase was rapidly truncated around 12,000 years ago by a cold, dry, and windy period known as the Younger Dryas (YD), when windstorms scoured and deposited loess over the paleosols. Many Clovis sites on the Delmarva Peninsula were destroyed by YD deflation, and their artifacts were redeposited, along with lag gravels, on the interface surface between the truncated Tilghman soil and YD deposits. It is unclear why the dates from the Tilghman soil are older than the Allerød/Bølling dates.[16]

Cactus Hill is roughly 80 miles across the Chesapeake Bay from the Eastern Shore, and it is highly likely that the paleosol separating the early occupation from the Clovis occupation at that site was formed at the same time and under the same environmental conditions as the Tilghman Paleosol.

Test excavations by Lowery at Paw Paw Cove on Tilghman Island, Maryland produced an in situ Clovis occupation level on the upper surface of the paleosol.[17] Moreover, many Clovis artifacts have been found in lag deposits on the surface of the paleosol at other localities on the Delmarva Peninsula. The stratified context of these artifacts is clear evidence of human activity in the area of the Miles River in Maryland during the LGM.

Additional evidence supporting an Atlantic LGM occupation comes from Oyster Cove,

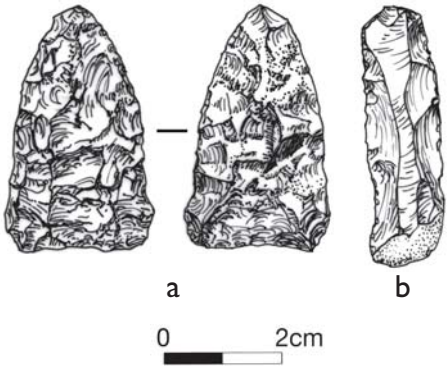


FIGURE 4.6.
Oyster Cove artifacts: (a) projectile point; (b) bladelet.

Virginia, where a projectile point similar to the one from Miles Point was found protruding from the Tilghman Paleosol exposed in a steeply cut bank (figure 4.6a). A small blade made from a chert cobble was also recovered from the beach (figure 4.6b). A bulk soil assay of carbon collected and combined from a soil sample provided an estimate of 25,800±120 RCYBP for the paleosol. While bulk soil dates may not be as accurate as dates from hearth features, the radiocarbon assays at seven different exposures of the Tilghman Paleosol on the Eastern Shore have all clustered within 1,000 years of one another.

During the spring of 2008 Lowery was conducting another shoreline archaeological survey, in Mathews County, Virginia.[18] While visiting the Gywnn's Island Museum, he noted a large Solutrean-style laurel leaf biface (figure 4.7) on exhibit with a mastodon third upper molar and tusk section. A label in the exhibit indicated that in 1970 the crew of the vessel *Cinmar* dredged all of these specimens at the same time while harvesting deep-sea scallops 100 kilometers off the coast of the Virginia Capes. In an interview with the vessel's captain, Thurston Shawn, Lowery determined that the artifact and mastodon remains came from a site approximately 75 meters beneath sea level on the outer edge of the continental shelf. Shawn mentioned that several other well-preserved teeth and tusk sections, along with skull bones, were distributed as souvenirs among the crew members. Because of the unusual nature of the assemblage, he took particular note of the water depth and plotted the area on his navigation chart.

From Shawn's bathometric information it is clear that the remains came from the LGM shore of the James Peninsula, adjacent to the South Lagoon of the ice age Chesapeake Bay (figure 4.8). The South Lagoon separated the mainland from James Peninsula Barrier Islands and created an excellent sheltered habitat for mastodons. It is likely that this combination of physiographic features also protected the site from erosion during the sea level rise at the end of the last glaciation.[19]

Lowery arranged for the Smithsonian Institution to borrow the artifact, tooth, and tusk segment for analyses.[20] The wear on the molar and the small diameter of the tusk tell us that the mastodon was a small female, about thirty years old when she died. A calibrated radiocarbon assay of collagen extracted from the tusk determined that she lived nearly

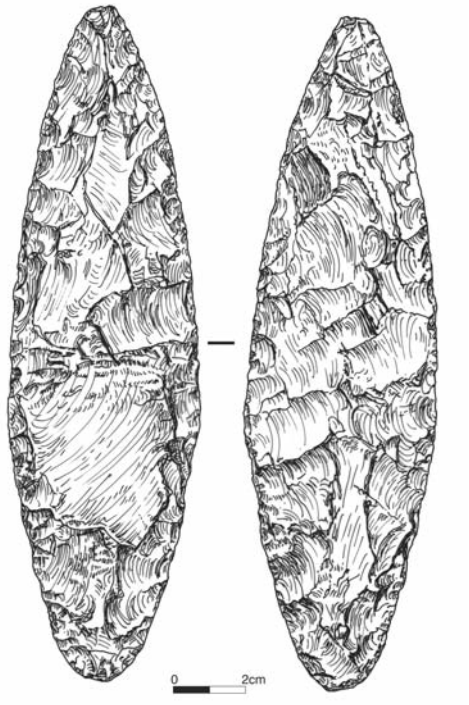


FIGURE 4.7.
Cinmar laurel leaf biface, obverse and reverse.

23,000 years ago. Based on LGM sea level calculations, the date is consistent with a terrestrial landscape; moreover, the site was beneath 15 meters of water by the time Clovis people occupied the Chesapeake region, indicating that this animal died long before Clovis people were in the area (figure 4.9).

The laurel leaf is 188 millimeters long, 55 wide, and 6 in maximum thickness. It exhibits well-controlled percussion-thinning flaking on both faces. Use-wear studies demonstrate that it was a hafted knife, and non-invasive retouch along its distal margins resulted from resharpening dulled edges. The use-wear traces are consistent with those found on prehistoric knives recovered from mammoth and mastodon butchering sites, as well as those seen on stone knives used during butchering experiments conducted on modern elephants. X-ray studies indicated that the knife is made from a banded meta-rhyolite from South Mountain on the Pennsylvania-Maryland border near Emmitsburg (figure 4.8).[21] The rhyolite used for this knife was of only fair flaking quality, leaving little question that the artifact was made by a highly skilled knapper. A much finer, better knapping grade of banded rhyolite was quarried at another locality, perhaps by the flintknapper who left waste flakes at the Thunderbird Clovis site near Front Royal, Virginia. This might indicate that the flintknapper who produced the Cinmar biface was unaware of the better quality stone that could be quarried elsewhere and that early Mid-Atlantic people had not yet thoroughly investigated the source area.

Although there is no definitive proof that the knife and the mastodon are part of the

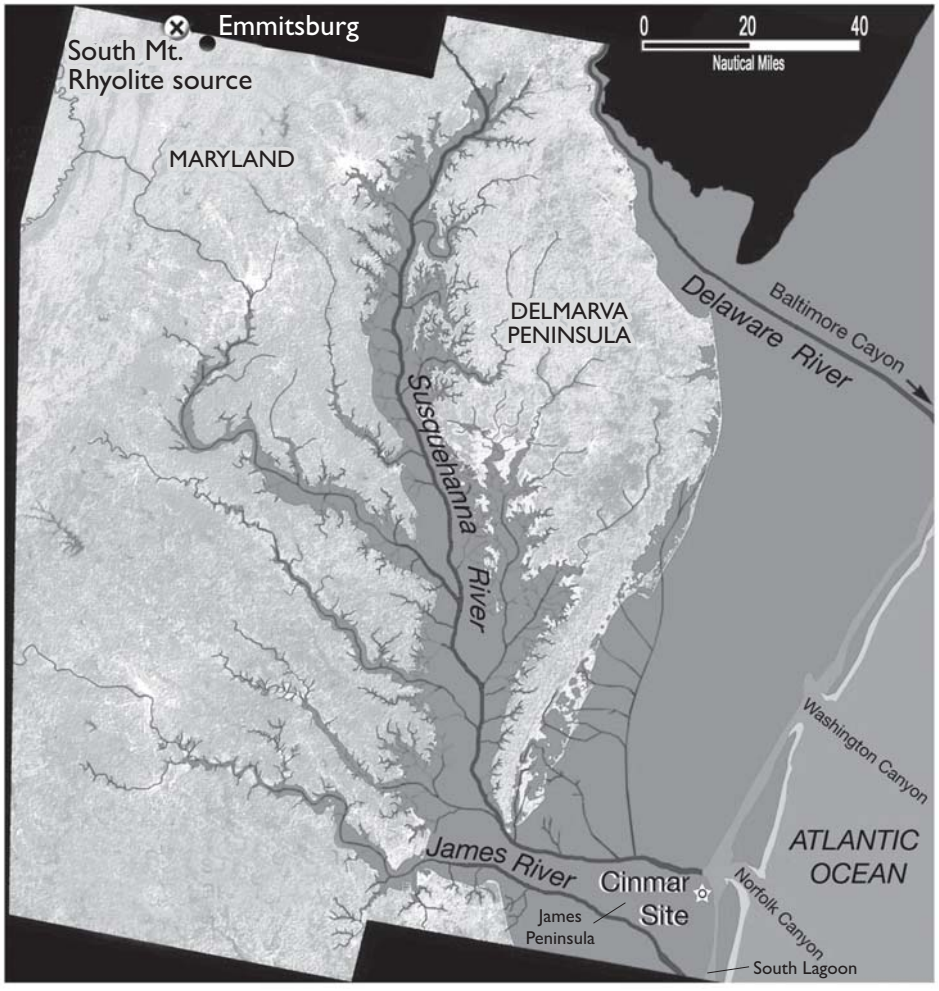


FIGURE 4.8.
Location of the South Mountain rhyolite source in the Chesapeake Bay region relative to the Cinmar Site at the time of the Last Glacial Maximum.

same archaeological assemblage, we contend that the clues from context in which they were deposited and the relatively undamaged condition of the knife overwhelmingly support their association. The edges of the blade are sharp, and there are micro-traces of knife use-wear on the distal surfaces and haft wear on the proximal end. The survival of these use-wear micro-traces indicates that the artifact remained in its primary context until disturbed by the dredge. Thus it was not tumbled, abraded, polished, or damaged by fluvial transport, wave action, or water transport of any kind until brought on board the *Cinmar*.[22]

The excellent preservation of the Cinmar mastodon remains resulted from their rapid burial in a freshwater peat bog. Mastodons were apparently attracted to ponds and bogs.[23] Freshwater springs, ponds, and peat bogs would have been common on the outer conti-

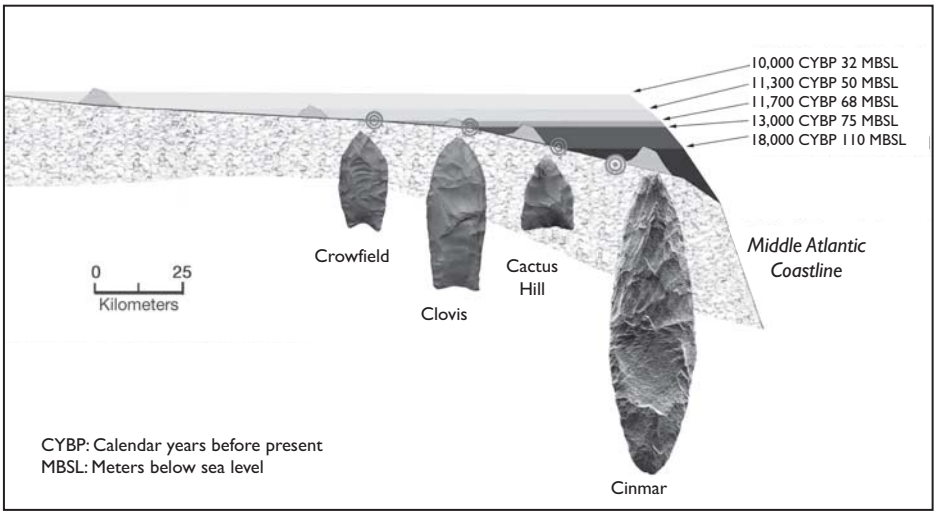


FIGURE 4.9.
Post LGM sea level rise over the continental shelf showing mean sea level at the time of culturally associated diagnostic artifacts between 23,000 and 10,000 years ago.

nental shelf during the LGM.[24] We suggest that Paleolithic people killed and butchered the mastodon while she was in or next to a bog. The knife was lost during this activity. The anaerobic bog environment preserved the bone for ten millennia without physical changes. Human remains were likewise preserved for thousands of years in peat bogs in northern Europe.

Near the end of the LGM, about 14,500 years ago, the collapse of the continental glaciers caused the sea levels to rise as much as 16 meters in a couple of hundred years.[25] The elevated sea levels breached the James Peninsula Barrier Islands and barrier island lagoons, briefly transforming the Cinmar peat bog into a low-energy saltwater tidal marsh. The knife, tooth, and tusk became lightly stained by iron sulfide and rust-colored iron oxide from oxidation by aerobic bacteria of the marsh. The tidal marsh in turn was also inundated by the rising sea level, causing oxidation of the knife and bone to cease. If the sea level's stabilization had left the knife in a salty environment for a significant period of time, it would have dissolved. But because of the fortunate location of the Cinmar Site on the west side of the barrier island lagoon, the knife was protected from ablation by tides and storms. With the isostatic subsidence—the pushing down of the earth's mantle by the weight of glaciers on the crust—of the James Peninsula, the site was likely buried in shallow ooze until disturbed by the dredges of the *Cinmar*. Whether or not the knife was used to butcher the mastodon, or even whether the two go together as an archaeological assembledge, the presence of the knife at this depth would indicate that it dates to the time before sea level rose at the end of the LGM.

The only other plausible scenario is that the biface was lost overboard by a later pre-

PRE-CLOVIS IN NORTH AMERICA?

In the fall of 1975, we had an encounter with the thorny issue of the existence of pre-Clovis in North America. A team of archaeologists and students including Bruce and me were finishing up the excavation of an 11,500-year-old bison kill known as the Jones-Miller Site in Colorado. A local construction operator, Gary North, came by the archaeological field camp with some large bones he had unearthed on a nearby farm. We identified the bones as mammoth, which went extinct in North America at the end of the last ice age. The next morning our crew dashed off to examine the area where North had found the bones. We soon realized that there were a lot of bones in the excavation pit and perhaps an entire mammoth might be found. We were especially hopeful that human artifacts would be associated with the beast. The farm owner, Junior Selby, gave us a few days to uncover the rest of the bones, so North decided to work on another of his projects, at the Dutton farm a few miles south.

As work progressed on the Selby farm, the geologist John Albanese determined that the bones were in a geologic level that dated older than 14,000 RCYBP (radiocarbon years before the present), at least 2,500 years before scientists thought the first humans appeared on the Colorado plains. However, some of the leg bones of the large animal appeared to have been intentionally broken to retrieve the fat-rich marrow. The absence of tooth marks suggested that someone had smashed these bones with a large, heavy object. If this was so, someone had broken these bones several millennia before the date of the earliest evidence of humans in North America. We therefore reasoned that some natural event would better explain how the bones were broken.

North soon returned, excited to report finding more mammoth bones, in his new excavation on the Dutton farm. The next morning found a small excavation team twenty miles south looking at more mammoth bones. A jawbone slightly exposed by North's large motor scraper stood in the way of construction progress. In an effort to salvage the specimen, the crew immediately began to excavate it from a geological deposit similar to that of the bones at Selby's. The context suggested that both finds were from the same pre-human period.

By mid-morning we discovered another bone lying next to the jaw. This too was mammoth bone, a short section of a rib that had been split by a series of blows along its margin. At one end it was beveled to a sharp point, which appeared to have become rounded and polished, perhaps through use as a tool.

Joined that evening by the teams from the bison kill and the Selby farm, we gathered over a warm stew to discuss the day's discoveries. Long into the stormy night we talked about the significance of the rib bone: Was it a tool made and used by a human more than 16,000 years ago? Or was there another explanation for its tool-like character?

These issues were all the more intriguing since all of us were well versed in the accepted scientific explanations of New World origins. In all our textbooks and classes there was very little doubt that Clovis culture represented the first Americans, who came from Asia some 14,000 years ago. If the bone we found at the Dutton farm was a tool, and if the relative date for it was correct, it would be an artifact that was older than Clovis, and our textbooks and professors would be wrong. This was our first personal brush with heresy. *Dennis*

historic sailor. But it seems highly unlikely that someone lost a knife overboard at that exact location and it came to rest in the relatively small area occupied by the mastodon remains. The odds against it are even greater given that this style of biface is extremely rare in the Chesapeake region. We asked a Smithsonian collection specialist to examine the museum's extensive archaeological collections for a technological match from Maryland, Virginia, Delaware, Pennsylvania, or North Carolina. He found only two matches, and little is known about where they were found or with what they were associated.

We have identified only three other laurel leafs in private collections in the region. One of these was found in sand that was dredged offshore to rebuild a beach after a hurricane, one came from a near-shore clam bed, and another was found eroding from a Pleistocene terrace of the Susquehanna River in Dauphin County, Pennsylvania.

Taken as separate collections, the Cinmar knife and the types of artifacts found in the lowest cultural levels at Meadowcroft, Cactus Hill, Miles Point, and Oyster Cove do not constitute large enough samples to characterize a cultural assemblage or flaking technology. However, if all five site assemblages are combined and treated as one complex, we begin to see a pattern emerge that includes laurel leaf–shaped bifaces, thinned biface projectile points, blades, burins, bladelets, polyhedral cores, and a host of non-diagnostic flake tools. We consider these tools to be a partial representation of a flaked stone tradition that is similar in many ways to Clovis, a variety of the Franco-Cantabrian Solutrean, and as it turns out, resembles the younger eastern Beringian Nenana Complex (see chapter 6).

CONTINUITY FROM CACTUS HILL TO CLOVIS

The main differences between Clovis point technology and the technologies of the earlier Mid-Atlantic assemblages is that the latter were made smaller and their bases thinned by the removal of a series of pressure flakes, not the distinctive fluting of the Clovis points. Thus the key issues for pinpointing the origins of Clovis are when and where purposeful fluting as a basal thinning technique came into use. We contend that people living in eastern North America perfected Clovis technology, so we examined both excavated and surface collections from the Mid-Atlantic and southeastern states. We found a wide vari-

ety of typological and technological treatments, ranging from straight through indented bases, with various amounts of pressure thinning, including unsuccessful attempts at fluting. If the unfluted Clovis-like specimens from the surface sites are proto-Clovis technology, their abundance suggests an early robust population in the southeast. That being the case, it is not surprising that a growing number of sites in the southeast have radiocarbon dates or stratigraphic contexts suggesting that they are proto-Clovis in age. Among these sites, Jefferson Island in Maryland, Page-Ladson in Florida, and Johnson and Coats-Hines in Tennessee are the most informative.

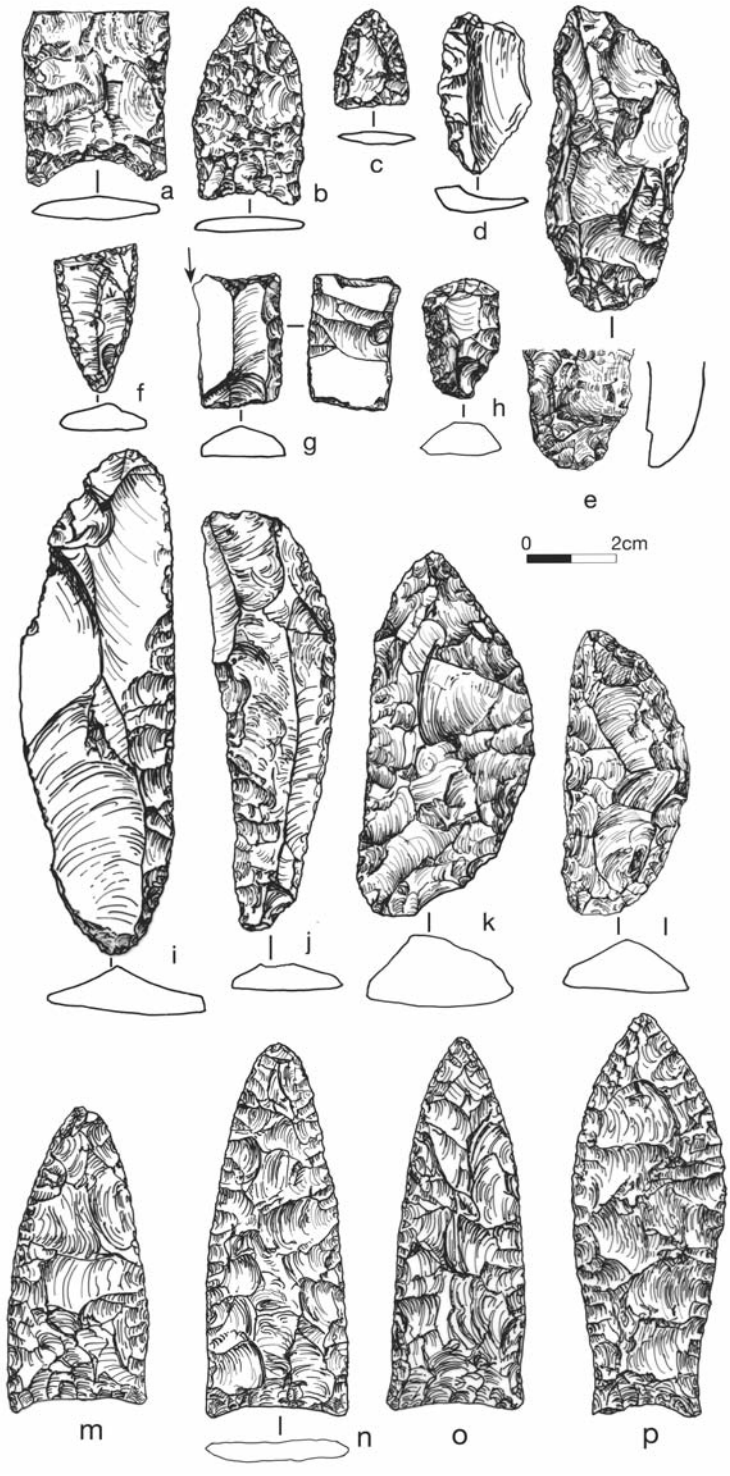
Jefferson Island in the Chesapeake Bay has produced unfluted Clovis-like projectile points along with an assemblage of other tools exposed in and eroding out of the Tilghman Paleosol.[26] This stratigraphic placement dates the site occupation to sometime between the LGM and YD climatic intervals (circa 13,000–25,000 years ago). Because of sea level rise the site is now on an island, but at the time of occupation it was situated on a terrace above the Susquehanna River. The projectile points (figure 4.10a–c) and blade tools (figure 4.10f–g) from Jefferson Island overlap the range of technological variation noted in both Cactus Hill and Clovis assemblages. Although the points are not fluted, they are basally thinned. Evidence of overshot flaking reduction is apparent from a tool made on an overshot flake (figure 4.10d). Among the blades and tools made on blades are two with abrupt steep edge retouch, one of which has flat flaking on its ventral surface and a possible burin scar (figure 4.10g), and two retouched blades (figure 4.10i–j). Two oblong, crescent unifacial scrapers (figure 4.10k–l), likely made on blades, were found along with a micro–end scraper (figure 4.10h), and an adze-like tool (figure 4.10e).

The relatively large size of these artifacts and the excellent raw materials used in their manufacture indicate that the Jefferson Island flintknappers collected their raw stone farther up the Susquehanna River, closer to or at bedrock deposits, than did the Miles Point knappers. Perhaps this difference indicates that exploration for and discovery of new resources over a wider geographic region took place in the years after the occupation of Miles Point.

Most of the Jefferson Island artifacts were collected from the intertidal zone, where they were eroded out of context onto the beach. However, a projectile point was found in situ but partially exposed in the Tilghman Paleosol. Since no other archaeological occupations occurred at this location, we suggest that all of these artifacts were once buried in the paleosol deposit and represent a single assemblage.

FIGURE 4.10.

Jefferson Island artifacts (a–l) and Florida pre-Clovis points (m–p): (a–c) projectile points; (d) overshot flake tool; (e) adze-like tool with outline of obverse side and reverse side showing bit and cross section of bit end; (f) tool with abrupt retouch made on the snapped proximal end of a blade; (g) snapped blade with abrupt edge retouch on the right dorsal edge, flat flaking on the ventral side of the blade, and arrow designating a possible burin scar; (h) microscraper; (i–j) retouched blades; (k–l) unifacial crescent scrapers/knives; (m–o) Page-Ladson points; (p) Suwannee point. Outlines show cross sections.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At the Page-Ladson Site in Florida, three unfluted, indented base projectile points were found (figure 4.10m–o), but unfortunately they were displaced from their original context. Still in situ, however, mastodon ivory and bones with cut marks were found associated with chert tools. Seven radiocarbon assays run on these bones average 12,420 RCYBP. The flake tools found with the mastodon and the weapon tips were made of a chert from the Flint River Basin in Georgia. And perhaps not coincidently, strontium-90 studies of the mastodon bone indicate that these animals also came from Georgia. This co-occurrence may be serendipitous, but the investigators think it highly probable that the points were originally associated with the mastodon.[27] Furthermore, the projectile points from Jefferson Island are technologically very close to the Page-Ladson points, and the former's stratigraphic placement in the pre-YD Tilghman Paleosol supports the assumption that the unfluted points found at Page-Ladson were, indeed, used to kill mastodons 14,600 years ago. It appears that all of these unfluted points are pre-Clovis and can provide information about the later stages of the development of Clovis technology.

The Page-Ladson points were originally grouped together with similar points under the name Suwannee (figure 4.10p). Suwannee points have now been divided into three types that may have temporal significance. The Page-Ladson type is thought to be the oldest.[28] The overall point morphology and manufacturing techniques, including overshot flaking, are similar to Clovis, but without the flutes. These artifacts are well known to archaeologists working in Florida, especially in the northern part of the state, where they are common, but they have a broad distribution, occasionally showing up along the eastern seaboard as far north as Delaware and as far west as central Texas, were they were found below a Folsom occupation at Horn Shelter near Waco.[29]

An undated collection from Harney Flats, Florida, based on its similarity to the Page-Ladson materials and dissimilarity to other materials in the region, helps to define the artifact assemblage content of this early Florida technology and reveals that the Page-Ladson-Suwannee lithic repertoire incorporated a well-developed polyhedral core and blade technology.[30] At the Ryan/Harley Site and other localities found by divers seeking relics in underwater sinkholes and channels along the Wacissa River, Suwannee points have been found associated with a wide range of extinct fauna, including Pleistocene horse, tapir, and mastodon.[31] A time span of 13,900–14,600 has been attained from worked ivory and butchered bone found at these locations, consistent with the dates from Page-Ladson. The excellent preservation conditions provided by the limestone sinkholes have expanded the variety of known ivory tools to include decorated beveled rods (figure 2.13e), a barbed point (figure 2.13f), and hooks for atlatl spear throwers (figure 2.13i–k).[32] Many of these items are also associated with chipped stone tools, but no diagnostic projectile points have been found. It is unclear whether these were part of the proto-Clovis or Clovis assemblages, but the radiocarbon dates from Page-Ladson indicate that hunters killed and processed mastodons in Florida prior to Clovis times.

Evidence of the final phase of proto-Clovis development comes from the Johnson Site, on the Cumberland River in downtown Nashville, Tennessee. This site was originally re-

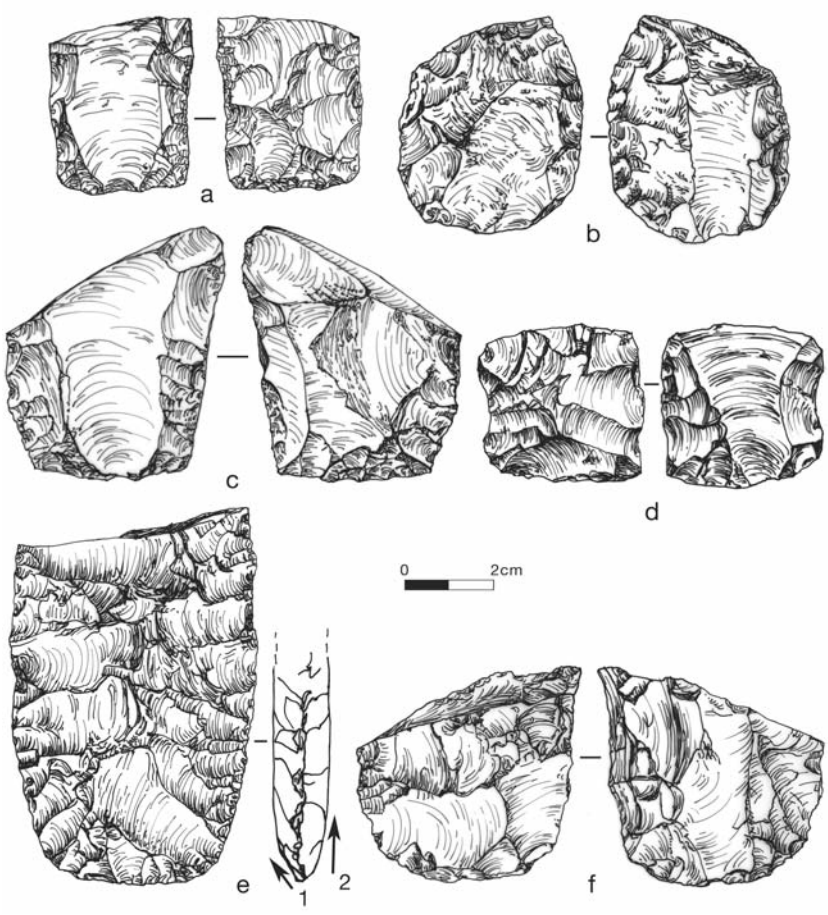


FIGURE 4.11.
Late-stage preforms from the Johnson Site (b, d, f) and Carson-Conn-Short Site (a, c, e) in Tennessee: (b, d, f) Proto-Clovis late-stage biface failures resulting from not preparing a beveled fluting platform; (a, c, e) late-stage bifaces showing typical Clovis beveled fluting platforms; (e1) platform bevel; (e2) face intended to be fluted.

ported as a Clovis occupation.[33] Twenty-six late stage preforms, all broken during final fluting (figure 4.11), were recovered from an occupation level, along with seventeen blades and blade tools, end scrapers, and miscellaneous flake tools, while other artifacts were found redeposited on the beach below the exposure. Three charcoal features from the occupation level dated to 11,700±980, 11,980±110, and 12,660±970 RCYBP, respectively. Though the standard deviations are large for two of the dates, we think the deviation for the third feature is within an acceptable range, and all three dates average about 14,000 years old. As these dates are at least 500 to 1,000 years earlier than currently accepted Clovis dates, some scholars dismissed the site as incorrectly dated or not a Clovis occupation.[34]

Because we accept the dates, we re-analyzed the assemblage and came to an unexpected

BEFORE THE BEGINNING?

In the 1970s, an archaeological excavation of a seventeenth-century colonial homestead on Eppes Island, Virginia, turned up an unusual biface. The investigators of the site recognized it as a Solutrean laurel leaf. They concluded that the biface, which they thought was made of French flint, was a relic brought to the New World by an early colonist.

Jeff Speakman of the Smithsonian's analytical lab conducted an X-ray fluorescence probe of the biface and compared the results to probes of French gun flints and Solutrean artifacts made of Grand Pressigny flint from France. The results indicated that the biface was made of French flint. Could this artifact be direct evidence of Solutrean settlers of the New World rather than a relic once owned by a seventeenth-century colonist?

Eppes Island is the remnant of an upland terrace located at the confluence of the James and Appomattox Rivers. This location would have been an excellent camping locality following the LGM. The biface and other prehistoric artifacts were found below a clay chimney base and thus were not likely to have been the possessions of a colonist. Because this is not certain, the laurel leaf is not the smoking gun of our theory, but it is an intriguing piece of evidence. *Dennis*

conclusion: these are not Clovis artifacts, but Southeast Early Paleo-American (proto-Clovis) artifacts! The assemblage includes a plane face point; two end scrapers, both retouched across their dorsal surfaces; and retouched blade fragments and bladelets. In addition, there are fourteen biface basal fragments, all of which were broken during late-stage fluting attempts gone awry (figure 4.11b, d, and f). This same breakage is also seen in some bifaces from the Carson-Conn-Short Site in Tennessee (figure 4.11a, c, and e). Unlike Clovis artisans, the flintknappers who ruined the Johnson Site bifaces did not prepare proper fluting platforms, instead striking the base of the biface no matter what its morphology.

Three alternative conclusions may be derived from this evidence: novice Clovis flintknappers were learning fluting techniques without the benefit of instruction (for instance, a youth might have been trying to emulate adult knappers); non-Clovis individuals were trying to replicate the technique, also without benefit of instruction; or proto-Clovis knappers were experimenting with basal thinning techniques. As there is no immediately available tool stone in the area, we doubt that beginners would have been allowed to practice on so many pieces of raw material without corrective instruction. Although the second scenario could be correct, there is little or no archaeological evidence of non-Clovis people living in the southeast during Clovis times. The total artifact assemblage along with the radiocarbon dates leads to the conclusion that the assemblage is a proto-Clovis technol-

ogy, and it is not surprising that its radiocarbon dates are older than the earliest accepted dates for Clovis.

The stratigraphic sequence confirmed by the radiocarbon-dated geologic exposures and associated artifacts indicates that people who used core and blade and bifacial projectile point reduction technologies were established in the Mid-Atlantic region of North America during the early LGM. As yet the data are not robust, but they suggest that a shift to fluting technology took place in the southeast, perhaps in Tennessee, around 14,000 years ago. There is no evidence of proto-Clovis fluting developments north or northwest of the Chesapeake Bay. Instead the smaller indented base projectile points and blades continued to be manufactured by people who moved along the margins of the LGM-YD Great Lakes region and perhaps onto the northern plains.

NORTH—AND WEST—TO ALASKA?

The rapid rise in sea level during the climatic warming after the LGM was not disastrous to human hunters and gatherers; on the contrary, as the sea flooded the continental shelf, it created a richer estuarine environment. At the same time, the Laurentide glacier retreated, opening new nutrient-rich inland territories with an expanding biota exploited by both man and beast. Increased biological productivity in both environments could sustain a significant increase in population.

People had no doubt explored inland from their arrival, and we think this process is recorded at Meadowcroft by the decreasing ages of the hearths. These probably represent short-term camps between 19,000 years ago and the latest Miller Complex occupation between 15,100 and 13,200 years ago. The most recent occupation appears somewhat more substantial than previous camps, and the distant sources of the raw materials represented in the later artifacts indicate that the occupants were familiar with a vast territory, presumably as a result of explorations by their ancestors during the previous millennia. As James Adovasio, the excavator of Meadowcroft, points out, this occupation is only slightly pre-Clovis in age.[35] Since the technology of the Miller bifaces does not overlap Clovis, we think that the developed Clovis innovations did not reach southwestern Pennsylvania until later.

There is possible evidence for a westward expansion from Cactus Hill of the basally thinned, indented base point style along the northwestward retreat of the Late Pleistocene ice margin (figure 4.1). For instance, in extreme southeastern Wisconsin, butchered mammoth remains were found associated with simple stone tools, but there were no projectile points at the Schaefer and Hebior sites. The archaeologist William Overstreet and his associates conducted eight radiocarbon tests on wood samples and collagen from the Schaefer mammoth bone.[36] The results were remarkably consistent, producing an average age of 12,373±75 RCYBP. They also obtained three collagen accelerator mass spectrometer (AMS) carbon-14 dates averaging 12,530±50 years RCYBP from the Hebior mammoth bone. (AMS takes smaller samples and is more accurate than conventional carbon-14

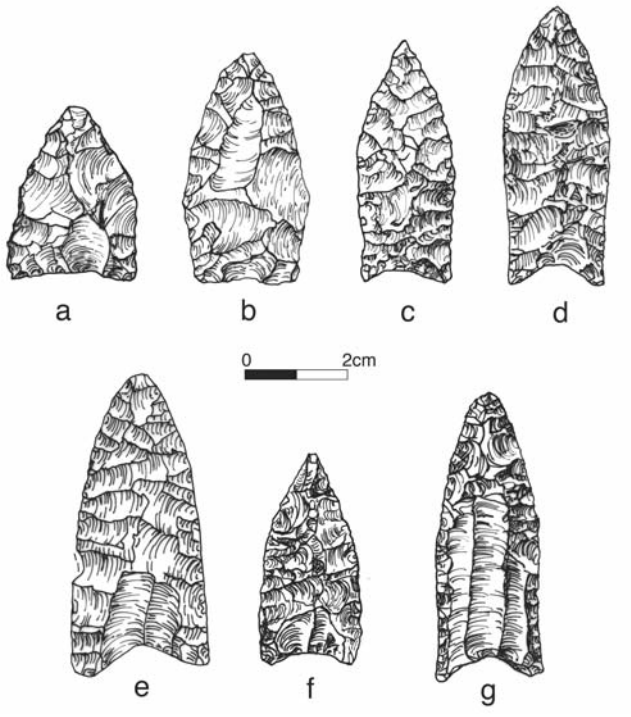


FIGURE 4.12.
Proposed periglacial point progression from the Mid-Atlantic seaboard to the Brooks Range of Alaska: (a) Cactus Hill; (b) Miller point from Meadowcroft; (c) Chesrow point type; (d) Goshen; (e) fluted point from Alberta; (f) Nenana; (g) Alaska fluted.

dating.) Thus there is no doubt that ice age hunters were stalking now-extinct animals near the glacial margin in Wisconsin contemporaneously with or slightly later than the youngest Miller Complex occupation at Meadowcroft. Furthermore, these events took place more than a thousand years before Clovis hunters killed mammoths at Blackwater Draw, New Mexico. Two additional Wisconsin mammoth sites, Mud Lake and Fenske, produced a tight radiocarbon age cluster of 13,500 RCYBP (16,050 years ago).[37] There is some evidence that these animals were butchered, but no associated stone tools were found.

Although no projectile points were recovered at any of these sites, Overstreet makes a case that the hunters used a type known as Chesrow (figure 4.12c).[38] Chesrow points and artifacts have been found at several campsites nearby on the Calumet Stage beach of glacial Lake Chicago, an early version of Lake Michigan. Based on a tentative correlation between the landscape positioning and elevation of two of the Chesrow sites and the high water levels of the lake during various climatically induced meltwater surges, he proposes that the Chesrow artifacts were made between 13,700 and 15,000 years ago. While this doesn't prove that the points were used to kill the mammoth, it may indicate they were contemporary.

Chesrow weapon tips are comparatively thick, basally thinned bifaces that were occasionally edge ground along the basal margins. Except for greater thickness, they are close to Miller points in overall morphology and manufacture (figure 4.12b). Since these tools are all made of poor-quality, cobble-sized residual cherts from local glacial deposits, their

relative thickness is likely due to the difficulties of working small, tenacious cobbles. Blades and blade cores have not been identified for this complex, so it is unclear how Chesrow might relate to the early Mid-Atlantic technologies.

The exceptionally early dating of mammoths with clear artifact associations is hard for many conservative North American archaeologists to accept. Because of the lack of a robust suite of radiocarbon dates for the Chesrow Complex, the arguments against its antiquity are nearly identical to those leveled against the pre-Clovis age of Suwannee. In light of age and technological correlations between the Wisconsin finds and Meadowcroft and Cactus Hill, however, Overstreet's interpretation seems reasonable.

The antiquity of these mid-continent human-mammoth associations is significant for the theoretical peopling of the Americas via the ice-free corridor. Paleoecologists and geologists now estimate that this route could not have been used before 13,000 years ago.[39] Since the butchers of the Schaefer and Hebior mammoths in Wisconsin were home long before the corridor opened, their ancestors could not have traversed this inland passage.

The environment of ice margins and the adjacent tundra remains a key factor in tracing when early pioneers first began to expand to the northwest. Excellent geological and pollen evidence, along with plant and animal remains, indicates that conditions were highly variable, depending on a host of interconnected factors such as elevation, latitude, and distance and direction to major water bodies and the edge of the glacier. This tended to produce ever-increasing environmental diversity as the glaciers retreated northward. Some areas were afforded protection from winds and storms; others basked in the sun; still others were in isolated cold air drainages that preserved islands of stagnant ice. Tundra likely gave way to patches of spruce parklands, while well-drained regions became grasslands. Much of the habitat was a mammoth steppe or temperate tundra, with spruce forest closing in on open spruce parklands.

This checkerboard of habitats was peppered with a liberal dose of wetlands, ponds, and lakes. As the glaciers ebbed, their underlying topography, depressed for eons by the weight of the once-overlying ice mass, became inward-slanting basins that collected meltwater. Some of these glacial lakes were so large that they are considered inland seas. Our Great Lakes are mere shadows of this once immense system of lakes. Inevitably water filled the basins beyond their capacity, breaching divides and spilling across the landscape to create new canyons, rivers, and wetlands. Glacial Lake Missoula in western Montana drained so rapidly that it carved out thousands of square miles of countryside, creating the vast scablands of eastern Washington. Before the ice retreated across the St. Lawrence spillway, the majority of the meltwater east of the Continental Divide drained into the Mississippi River and significantly lowered the temperature of the Gulf of Mexico.

The melting of the continental glaciers was neither a constant nor a consistent process. During episodes of global cooling the glaciers advanced, retaking healed landscapes. Some of these fluctuations resulted in ice fronts advancing and retreating as much as 500 kilometers in just a few hundred years. These re-expansions no doubt destroyed evidence of the activities of earlier ice age hunters.

As the glaciers gouged their way across the earth's surface, they abraded the underlying basal rock into a fine-grained mineral powder known as loess. Some of the crushed rocks contained phosphates and potassium, essential nutrients for plant growth. Substantial concentrations of formerly atmospheric nitrogen that had accumulated in the ice sheets for thousands of years were also deposited on the periglacial landscape as the ice front melted. With such high concentrations of fertilizer along the margins of the ice sheet, plants would have begun growing relatively soon and been especially nutritious to the herbivores grazing in these areas.[40] The result would have been a potentially greater number of herbivores and their predators. Vast amounts of loess were blown south and east by catabolic winds—which occur when air cooled by moving over a glacier meets warm air over land—and deposited in deep beds in the upper Midwest, creating extremely productive rangeland there as well.

Different animals exploited different environments. Caribou herds and moose were no doubt major components of the temperate tundra, while other ungulates grazed on the margins of the spruce parklands and down into the forests. Mammoth, horse, bison, and camel fed on the drier grasslands, scattered among sage and stands of pioneer trees and sun-tolerant shrubs. As the nutrient-rich lake basins warmed and bloomed, migratory waterfowl no doubt flocked to them for summer breeding grounds.

The new environment bursting forth was ideal for hunting societies, and there is little doubt that ancient human bands moved into it. The same act was playing out all over the Northern Hemisphere as ice age climates gave way to the warmer regimes enjoyed today. But traces of the passing of prehistoric humans are difficult to find; most were destroyed by the dynamic geological processes that were resculpting the landscape, especially soil upheavals caused by frozen ground phenomena, such as ice wedges and solifluction, and tongues of ice expanding across the plains.

If the thin indented base point is an index fossil of early human population expansion, it should have been encroaching on the plains and moving northward through the ice-free corridor as environmental conditions allowed, through a succession of styles. An enigmatic complex known as Goshen (figure 4.12d) from sites on the northwestern plains contains thin unfluted points that might be later relatives of the Miller Complex. Dates from the Mill Iron Site in eastern Montana of circa 11,500 RCYBP (13,350 years ago), as well as those around 11,100 RCYBP (13,020 years ago) from a Goshen occupation at the Jim Pitts Site in South Dakota, suggest that people were hunting bison on the northern plains while Clovis were beginning to push westward.[41]

Projectile points from Alberta also indicate that descendants of the early indented-base-point folks colonized the ice-free corridor as soon as the environment could sustain animal life (figure 4.12e). This process no doubt took place much earlier along the warmer southern end of the corridor than it did in the north. In fact, one can imagine the opening as convergent melting from both ends, but starting first and continuing more rapidly in the south as it moved north, east, and west to the mountains. Although it is theoretically possible that people traversed the entirety of the corridor by as early as 14,000 years

ago, fossils from the area, with few exceptions, are younger than 13,200 years old. As soon as the plains of Alberta were habitable, fauna with southern affinities moved northward, including horses and the plains bison, *B. bison antiquus*. The first evidence of its Arctic cousin, *B. bison occidentalis,* appeared at the Tabor Site near the far southern end of the corridor between 10,000 and 10,500 RCYBP (11,480 to 12,520 years ago). According to Mike Wilson, a prehistoric bison specialist, "These northern bison may signal not the physical opening of the corridor (for that was likely earlier), but the biotic opening of the corridor."[42]

One can only guess how long it took the northern bison to move south to Tabor, but they might have passed the human migrants who were moving north around 12,900 years ago and who left traces at several sites in Canada and central Alaska. It was in this general region that they interacted with the Asian makers of microblades who came across the Bering land bridge, creating the Nenana Complex, which has a median age of roughly 11,500 years. Like the other artifacts discussed in this chapter, Nenana projectile points (figure 4.12f) are very similar in size, shape, and technology to the Miller projectile point type. The Nenana people, like Chesrow and early Goshen people, did not have a well-developed blade component in their tool inventory—whomever they descended from, they did not retain this form of technology. The remainder of Nenana artifacts, including ivory rods and basic biface technology, are somewhat similar to Clovis. Some investigators accept that Nenana is in some way ancestral to Clovis, whereas others opt for a common ancestor. We prefer the latter point of view but differ in the identification of the common ancestor and its place of origin. Finally, we see the Alaskan fluted point as a possible fusion between the unfluted early indented base points and a microblade technology (figure 4.12g). Unlike Clovis fluted points, Alaskan fluted points exhibit scars indicative of pressure removals that are also quite similar to scars on pressure microblade cores.

Though some as yet unknown technology along the trail from Lake Baikal in south central Siberia to North America may have given rise to the Nenana Complex, in total or in part, we contend that the spread of early Mid-Atlantic technology shows an east to west cline—not west to east across the northern margin of Europe to Asia, as suggested by some geneticists, but westward across the Atlantic. Successfully adapting to new and enriched environments, the migrants who used this technology nearly circumscribed the globe.

5

THE SOLUTREAN

Ice Age Innovators

Since the Beringian evidence includes no suitable, old enough archaeological assemblage that might have given rise to pre-Clovis and Clovis technology, the question is, where in the Paleolithic world was there a technology that shared enough traits with them to suggest a historic relationship? For years scholars have noted superficial similarities between Solutrean and Clovis tools and technologies, but several seemingly irresolvable obstacles have prevented them from postulating a historical connection—chiefly a gap of some 5,000 years and the conviction that Paleolithic peoples could not have crossed the Atlantic Ocean.[1] But we now have pre-Clovis artifact assemblages in North America that overlap Solutrean in age (see chapter 4), and the evidence of very early sea navigation is growing (see chapter 10). It is time to give the Solutrean a more careful look.

UPPER PALEOLITHIC CULTURES OF SOUTHWESTERN EUROPE

The Upper Paleolithic in southwestern Europe has been divided into several major cultural periods based on stratigraphic relationships and changes in artifact types. Stone tool manufacture changed from modifying flakes during the Middle Paleolithic to making and using prismatic blades. Large blade technologies are the hallmark of the Upper Paleolithic, especially in areas rich in flint resources. This holds true throughout most of Europe, western Asia, and northern Africa.

Although our particular interest is a single period (16,500–25,000 years ago) in southwestern France and northern Spain, this brief overview of the European Upper Paleo-

lithic sequence places our observations and interpretations into a broader archaeological and cultural context. This is important because it shows just how different and special the Solutrean materials were, even in their homeland. Keep in mind that these are generalized summaries combining many materials that may have wide ranges of variation through time and space.

AURIGNACIAN (CIRCA 33,000–27,000 YEARS BP)

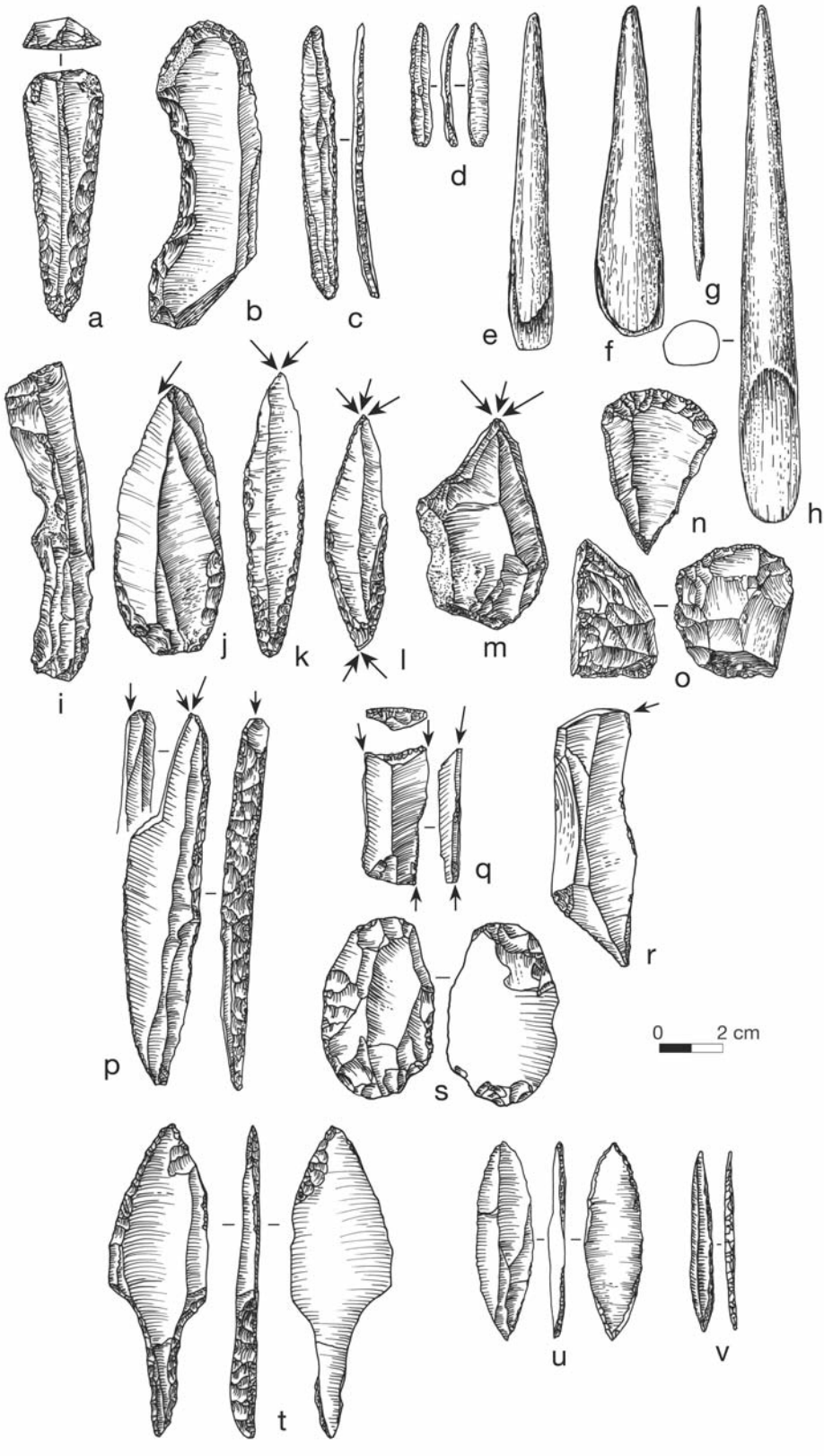
There have been heated discussions among European prehistorians about whether the Aurignacian archaeological culture, named after the location in France (Aurignac) where it was first recognized, represents a single flaked stone industry with variations or multiple independent industries, and it is subdivided into various units that identify time and space differences. However, the general similarities between the artifact assemblages and subsistence and settlement patterns of its users link them in a unified archaeological culture. Many researchers view the Aurignacian as a direct development from the preceding regional Middle Paleolithic industries rather than an intrusion, but this interpretation is now hotly contested.[2]

During this period the main flaked stone technology was blades produced from prepared cores, but there was also a significant component of tools made on flakes. Blade core preparation was primarily full bifacial edge trimming to form a guiding ridge, which was often retained on the back of the core throughout the flaking process. The dominant tool forms were blades with one sharp cutting edge and the other edge dulled or backed. Edge retouch tended to be abrupt. Blades were modified to produce scrapers (figure 5.1a–b) and projectile points (figure 5.1c). Backed bladelets were also present (figure 5.1d). Some of these tools have been given specific names, such as Châtelperron points and Dufour bladelets. Other distinctive tools are blades with notches (figure 5.1i), burins (figure 5.1j–m), end scrapers on flakes (figure 5.1n), and thick narrow scrapers (figure 5.1o). Many analysts now think that the last may have been bladelet cores rather than scrapers.[3] Along with stone tools, Aurignacian assemblages included distinctive split-base bone points (figure 5.1e–f), bone awls (figure 5.1g), single-bevel sagaie points (pointed on one end, beveled on the other; see figure 5.1h), and bone or antler batons.

Animal and abstract representations began some 34,000 to 30,000 years ago. These artistic expressions took the form of engravings and paintings on cave walls and small portable items. The general style remained fairly constant during the Aurignacian, but specific aspects of the representations changed with time and location.[4]

GRAVETTIAN (CIRCA 27,000–20,000 YEARS BP)

The Gravettian, named after La Gravette, France, seems to be a continuation of the Aurignacian with slight changes in the forms and proportions of the tools. Blade core preparation remained basically the same, with evidence of a distinct preference for bidirectional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opposed platform cores, and blades became even more dominant as the primary blanks for tools. Burins continued to be a large proportion of the tools, with some forms distinct enough to be given names, such as Noailles, Bassaler, and Raysse (figure 5.1p–r). Backing was still abrupt (figure 5.1p and u), but the forms of so-called Gravette points were straight and narrow (figure 5.1v). Small backed blades became more common, and a distinctive tanged point, called Font Robert, was introduced (figure 5.1t). Truncated blades (with an end removed by abrupt retouch) were also common. Split-base bone points were no longer present, but sagaie forms were retained.

Art in the form of cave paintings and portable items exhibited stylistic changes but little other alteration.[5] However, Gravettian artisans occasionally produced human figurines, including the Venus figurines.

SOLUTREAN (CIRCA 25,000–16,500 YEARS BP)

Chronologically, where present, the Solutrean follows the Gravettian, but since we expand the Solutrean discussion significantly, we defer it to later in this chapter.

MAGDALENIAN (CIRCA 16,500–13,000 YEARS BP)

The Magdalenian, named for La Madeleine, France, comprises a series of phases defined by the presence and absence of specific tool types or the introduction of new tool forms, especially bone artifacts. Although there is marked regional variability, the basic assemblages are all characterized by blade and bladelet technologies, with many of the tools undergoing a size reduction in relation to the preceding archaeological cultures. Tool assemblages varied considerably between sites, evidently mostly due to differing site functions. Some tool types continued from earlier times, including borers (figure 5.2a), burins (figure 5.2h–j), and backed blades (figure 5. 2k–l). New tool forms were introduced, including blade insets (figure 5.2b), microliths (figure 5.2c–d), and simple shouldered points (figure 5.2n). True barbed bone harpoons (figure 5.2e and g) and inset bladelet antler and bone points (figure 5.2f) became common during this period. Bone and antler carving was elaborated in highly decorated spear throwers and other implements.

One of the basic traits of the Magdalenian people was their ability to adjust to the changing environments at the end of the ice age, and many regional and local adaptations can

FIGURE 5.1.
Aurignacian (a–o) and Gravettian (p–v) artifacts: (a) end scraper made on blade; (b) end/concave scraper made on blade; (c) projectile point; (d) backed bladelet; (e–f) split-based bone points; (g) bone awl; (h) sagaie; (i) notched blade; (j–m) burins, with arrows indicating the direction of burin spall removal; (n) end scraper on flake; (o) thick narrow scraper; (p–r) burins; (s) retouched flake; (t) Font Robert point; (u) retouched blade; (v) Gravette point.

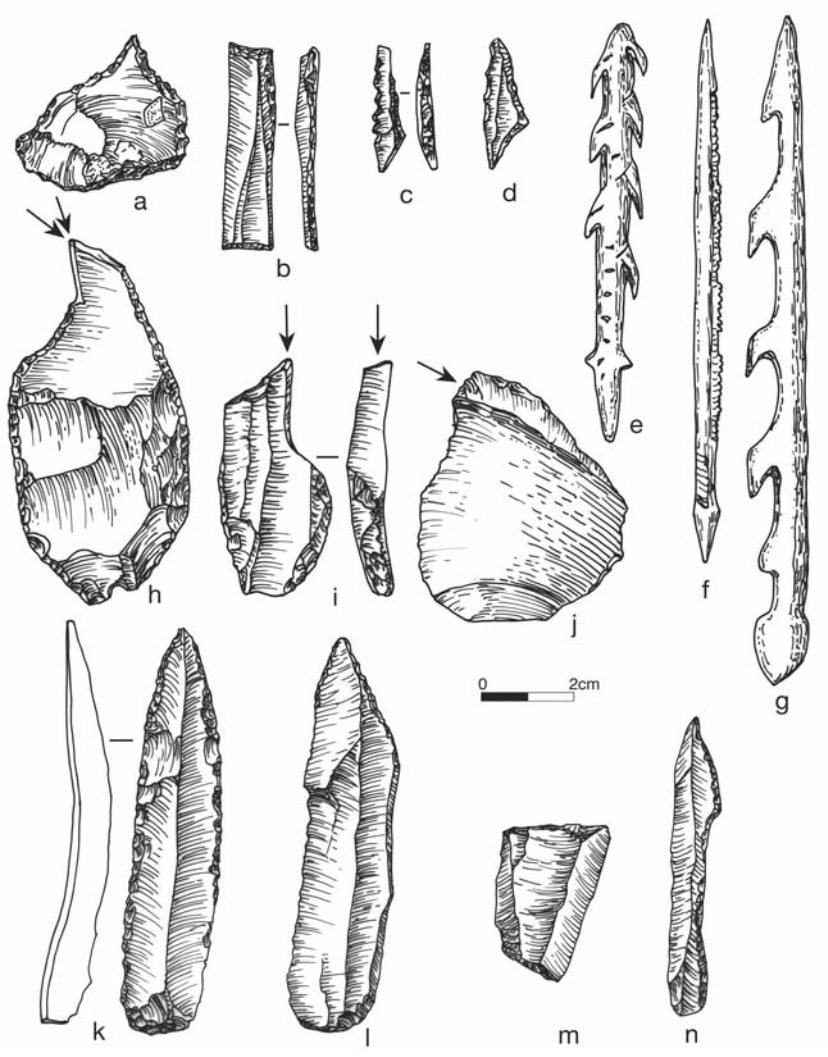

FIGURE 5.2.
Magdalenian artifacts: (a) borer; (b–d) microliths; (e and g) barbed bone points; (f) bone point with microblade insets; (h–j) burins); (k–l) retouched blades; (m) truncated blade; (n) shouldered point.

be recognized in the archaeological record. These are most evident along the margins of the seas, where people continued to improve their ability to exploit marine resources.

Although the genesis of the Magdalenian may be questioned in any given region, the lack of bifacial technology and the presence of a blade/bladelet technology, as well as the general tool assemblage, indicate that it was a continuation of the Aurignacian and Gravettian complexes. Only a few elements might have had Solutrean antecedents. One of these is rock art. The Magdalenian is best known for the florescence of art in the form of cave paintings and engravings, including at the amazing sites of Lascaux in southwestern

THE TYPE MINDSET

In the summer of 1999 I was privileged to work with a Spanish colleague, Carmen Cacho Quesada, at Tossal de la Roca in eastern Spain. She had been investigating the rock shelter there for years, and the radiocarbon dates and stone tool typology and technology had convinced her that it was a Magdalenian occupation. This interpretation was criticized by colleagues because Carmen had not found barbed harpoons, which some consider necessary to call an assemblage Magdalenian.

Carmen saw the site as an upland, probably seasonal dwelling for exploiting terrestrial resources, primarily rabbit and goat, and questioned why anyone would expect to find marine exploitation tools at an inland site. Certainly the people who lived there would have been smart enough to use the appropriate tools, at least as defined by their tradition, to catch their food. This argument, however, had fallen on deaf ears. Without barbed harpoons it could not be Magdalenian, according to some archaeologists.

On the very last day of our work at Tossal we uncovered several stone artifacts and some animal bones in one of the units. We left these for mapping, but it turned out that one of the partly exposed bones was a barbed harpoon point! With the find of this single artifact, Carmen's interpretation that she was working in a Magdalenian site was vindicated in the minds of some of her critics. It amazes me how a single artifact can be seen to change the entire cultural interpretation of a site, and even an entire ecological zone. *Bruce*

France and Altamira in northern Spain—although direct accelerator mass spectrometer dating of the pigments has moved some of these back to Solutrean times. Ornaments and decorative art on many portable objects, such as bone tools, became more common.

THE SOLUTREAN

The Solutrean is similar in many ways to the southwestern European industries discussed above. Where the Aurignacian, Gravettian, and Magdalenian, including regional variants, were widespread throughout glacier-free western Europe, the Solutrean was more limited in geographical distribution (figure 5.3). Although some flaked stone traditions in Portugal and Mediterranean Spain have been identified as Solutrean, we focus our attention on southwestern France and northern Spain, where we see the highest degree of technological similarities with pre-Clovis and Clovis.[6]

The Solutrean was first identified during early twentieth century archaeological work in cave deposits that yielded some of the most beautiful stone tools from the entire Paleolithic era. Many were exquisitely formed, and the flaking is quite elegant. They also tend

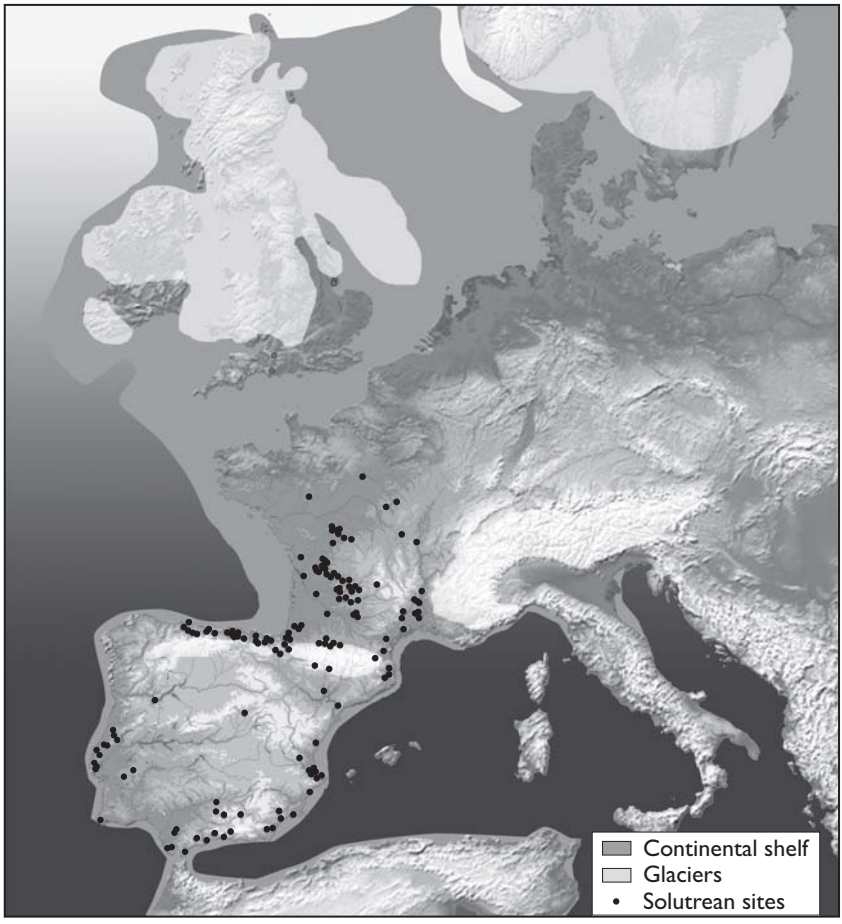

FIGURE 5.3.
Solutrean site distribution, glaciation, and landforms of northwestern Europe at the Last Glacial Maximum.

to be made from unusual and colorful stones. It is unfortunate that Solutrean artifacts were so attractive to collectors, because many of the deeply stratified cave sites that contained them were dug out with little care before World War I.

The name *Solutrean* derives from Solutré, near Dijon in east-central France, where the distinctive artifacts were first systematically described. Although considered the type site, Solutré has turned out to be peripheral to the main area of Solutrean occupations, and the site had limited activities. This mirrors many North American Paleo-Indian finds, particularly Clovis.

Solutrean deposits generally correspond to the last major glacial period, between 25,000 and 16,500 years ago. Many sites were excavated, under less than controlled conditions, before radiocarbon dating was developed, and the validity of their dates has been seri-

ously challenged.[7] Nevertheless, detailed stratigraphic and depositional analyses, combined with typological investigations, have produced a reasonably reliable chronology.

Philip Smith published a comprehensive summary of the Solutrean in 1966, and his book remains the most thorough discussion of the topic.[8] Little research was published on the Solutrean between then and the autumn of 2007, when a Solutrean conference was held in France to update the subject. Since the appearance of Smith's book, a few modern excavations of Solutrean sites have been conducted in France and northern Spain, and new methods have resulted in new insights[9] In particular, Lawrence Straus of the University of New Mexico, Les Freeman of the University of Chicago, and their Spanish colleagues, including Jesús Altuna and María Dolores Garralda, have conducted excellent work in northern Spain and published detailed site reports, overviews, and interpretations.[10] Much of what follows is based on Smith's and their work, in addition to our own research and examinations of museum collections.

ENVIRONMENT

The Solutrean people lived during the last ice age, when the climate was much colder than it is now. The phrase *ice age* conjures up primal thoughts and anxieties in many minds. *Alley Oop* and other cartoon characterizations of ice age peoples have established stereotypes of fur-clad people, mammoths, and perpetual snow. Like all stereotypes, these portrayals are not exactly, or even close to, reality. Our own contemporary experience tells us that there is a great deal of fluctuation in climate, both short and long term. We need only recall the American dust bowl of the 1930s or the occasional unusually severe or mild winters to realize how quickly weather patterns and climates can shift. During the Last Glacial Maximum (LGM), weather conditions were on average colder than at present, but there were major episodes alternating from warm and moist to cold and dry.

Paleoclimatologists have reconstructed the shifts in the climatic trends of southwestern Europe during the several thousand years of Solutrean culture. In the earliest period the weather regime was relatively wet and temperate. By middle Solutrean times the climate had shifted to a cold, drier phase, and it returned to warmer and wetter conditions at the end of the Solutrean. These climatic changes generally do not appear to correlate with the major phases of Solutrean culture; they were ongoing processes rather than sudden events and were not necessarily simultaneous in different regions. When France became colder and drier, Spain was still relatively mild and damp. The impact of these changes also varied with latitude and elevation, with micro-environmental contrasts existing on a local scale. For instance, sheltered or south-facing areas were likely to have more moderate weather conditions than open plains or higher plateaus. We also see changes in the distributions of plants, animals, and the people who depended on them corresponding to climatic changes during this period.

During the LGM a great deal of Europe was covered with ice and snow, including the

Pyrenees Mountains, which separate France and Spain, and the Picos de Europa and some of the smaller mountain ranges in Spain. The Fennoscandian ice mass blanketed most of Europe, effectively reducing the amount of land available for habitation and probably pushing people south and west out of the northern European plain. However, as glaciers lowered the sea level by capturing much of the earth's water, the North Sea drained, connecting the British Isles to the European mainland. While some habitable areas were shrinking, this climatic process opened up vast new territories for people to live in and exploit, most of which are now submerged.

Having been stationary for much longer than our present shoreline, the late glacial shore is likely to have been a well-developed depositional coast in many places, and rich in resources. This was mainly because of the large amount of seawater that was used to form the ice caps and glaciers. We have seen a major rise in the mean sea level over the past 8,000 years, which has meant relatively fast changes in coastlines. By contrast, cold, dry winds blew off the glaciers and swept across the plains of Spain, pulling the moisture from the grasslands and rendering them unattractive to man and beast. It is generally thought that during these cold periods, humans in this area followed animals to more suitable environments, along the shores of the Mediterranean and the Atlantic. The Gulf Stream shifted southward from the north Atlantic during the LGM, warming the southern coast of Portugal and tempering the Arctic waters that carried icebergs into the Bay of Biscay.[11] The ocean waters along the coastlines of southwest France and northern Spain teemed with life. Periwinkles and arctic cod thrived in the cold waters of the bay, and walrus, seals, and numerous types of fowl plied the ice leads in search of sustenance.

SETTLEMENT PATTERNS

When the Solutrean becomes identifiable as a distinct culture and where it was distributed through a 3,000-to-4,000-year period are subject to considerable debate. Theories about its origins range from in situ local development resulting from adaptation to the changing glacial environment, through migration into the area by new people, to diffusion and adoption of new technologies by existing cultures.[12] This is not our concern here, but if it were shown that the Solutrean immigrated into the area, one could reasonably suggest that mobility was one of their cultural traits, which might explain later movements into other new areas.

A real problem in interpreting Solutrean culture is that virtually all known sites are either in shelters at the base of cliffs or in caves. This sample bias deprives us of knowledge about a major portion of their settlement pattern and the activities that took place in open areas. At least some of this selectivity can be attributed to archaeologists who considered only cave sites to be of interest, a notion prevalent in southwestern Europe, especially during the past two centuries. The Paleolithic archaeologist James Sackett has dubbed this the cave mentality.[13] Cavemen live in caves, right?

Certainly this cave-oriented site pattern cannot represent the total settlement or use

of the landscape. Even if the Solutrean people were highly selective in the location of their habitation sites, they must have had hunting, foraging, and procurement camps away from cliffs and caves. The natural distribution of the animals hunted by the Solutrean people suggests that more open-air sites would have been occupied. There are a few reasonably well-documented open sites: Solutré, a horse and reindeer kill and butchering site on the eastern margin of the Solutrean culture area, and Saussaye-Tercis, on the south-central margin.[14] Les Maitreaux, a small open-air flint procurement and manufacturing site near Bossay-sur-Claise in southern Touraine, France, is being investigated as well.[15]

Surprisingly, no open-air Solutrean sites are known in northern Spain. One could argue that these types of sites are small and difficult to identify in a landscape where agriculture has been practiced for thousands of years, but open-air sites are common from the earlier and later Upper Paleolithic, especially Magdalenian times, and even from the Middle Paleolithic (for instance Corbiac, near Bergerac). Where are the equivalent Solutrean sites? The archaeologist Philip Smith, who wrote the seminal work on Solutrean, documented isolated surface finds of Solutrean laurel leafs that could have come from more extensive open sites, but none has been described.[16] We suspect that there may be a geological explanation for the lack of open-air Solutrean sites, such as an extensive erosional cycle between the end of the Solutrean and the beginning of the Magdalenian, around 16,000 years ago.

The rugged, steep foothills of Spain's Vasco-Cantabrian region would have been less conducive to open-air campsites than areas on the continental shelf exposed by a sea level that was as much as 130 meters lower than it is today. At its maximum extent this was more than 20,000 square kilometers of limestone landscape, now covered by the Bay of Biscay. The archaeologists Jean-Philippe Rigaud and Jan Simek have cautioned us to remember that between one- and two-thirds of the land surface available in Late Pleistocene Aquitaine now lies beneath either the sea on the continental shelf or the vast sand mantle of the Landes of southwestern France.[17]

The one thing that almost everyone agrees on is that the Solutrean distribution was much more restricted than those of the preceding Gravettian or the subsequent Magdalenian. The boundaries of Solutrean settlement are unclear, but at no time were these people completely cut off from adjacent areas with other Paleolithic populations. It is also apparent that there were minor territorial expansions and adjustments through time, and the inhabitants of some cultural boundary areas seem to have maintained their technology and lifestyle while those in the center continued to change. For example, indented base projectile points are restricted to northern Spain and the western Pyrenees. This is an extremely important observation to keep in mind, as our hypothesis does not envision a North American–founding Solutrean population to have necessarily possessed all of the Solutrean technology or tool kit.

Few Solutrean settlements are far from a major river or one of its larger tributaries. Lawrence Straus of the University of New Mexico sees the river valleys of northern Spain that drain the Picos de Europa as the primary territories of Solutrean bands, with little

cross-valley interaction. The river valleys were important for shelter, he suggests, and also provided food resources.[18]

Although the special nature of some of its flaked stone technology makes it tempting to see Solutrean as basically different from other Upper Paleolithic cultures in southwestern Europe, in terms of subsistence behavior it fits well into the general European pattern of a land-based Paleolithic hunting economy. This changed approximately 6,000 years ago, when some groups began to exploit the coastal and marine resources of the newly inundated areas of the Bay of Biscay, where many known Spanish Solutrean sites are relatively short distances (10–15 kilometers) from the ancient shoreline. Most submerged shore areas have been inaccessible to archaeological investigation, but underwater archaeological techniques have made amazing strides during the past few years, and the discovery of a French cave with a submerged entrance and rock art indicates that systematic exploration along the limestone cliffs of the northern coast of Spain and under the Bay of Biscay might be rewarding.[19]

SUBSISTENCE

The faunal remains found in Spanish Solutrean sites indicate that red deer, an animal closely related to the North American wapiti, and a small pony were the most common animals hunted by Solutrean people. Ibex, chamois, roe deer, and occasionally several types of bovines and wild pigs were also hunted, but their remains are far less numerous. In southwestern France, reindeer and horse dominate middens, but the bones of other beasts, such as bison, aurochs, musk ox, and saiga antelope, are also present in small numbers. Mammoths are represented only by ivory. Added to these remains are those of other species that were no doubt eaten but may have been killed primarily for their pelts and feathers.

In addition to traditional terrestrial food, especially in northern Spain, the resource niche expanded to include anadromous fish species, which live in salt water but breed in freshwater, such as salmon, salmon trout, and brown trout. Enough shellfish have been found at La Riera and Altamira to indicate they made an economically significant contribution to the diet. There are also a few seal flipper bones. Straus has concluded that the seal bones are from animals that were stranded on the beach, but cave art suggests that Solutrean people hunted seals, deep-sea fish, and sea birds.[20]

Although there are relatively few shellfish and other sea animal remains compared to those of terrestrial animals, remember that the Solutrean coastline is now submerged. Even if the beach were only 10–15 kilometers from sites such as La Riera, can we reasonably expect the maritime remains found in the cave site to represent the true degree of Solutrean exploitation of these resources? In an interesting study Douglas Bird found that although shellfish have been a common and dominant part of the subsistence of ocean edge people worldwide, very few of the shells or tools used to exploit the estuarine environment made it inland more than about a kilometer.[21] If this is a reasonable analogue of the northern Spanish Solutrean, the presence of any number of marine shells

in midden deposits at sites such as La Riera may actually represent significant maritime exploitation.

During Solutrean times the climate deteriorated from mild and humid to drier and colder. These latter conditions lasted until near the end of the Solutrean, when there is evidence of increasing moisture. In spite of these changes most authors consider the environmental conditions of the northern Spanish coast to have supported reasonable herds of bison and deer.[22]

ARTIFACTS MADE FROM PERISHABLE MATERIALS

As far as we know no one has ever found a Solutrean spear, yet we never question that spears were part of the weaponry. Artifacts made of fiber, wood, hide, and other perishable materials probably far outnumbered the durable artifacts and possessions lost or abandoned at sites, yet it is primarily the latter that have survived through the ages and are the specimens archaeologists rely upon to make their major technological and cultural interpretations.

Even if the perishable items have disappeared, however, all hope is not lost. Jim Adovasio, Olga Soffer, and Bohuslav Kléma have shown how careful examinations of sedimentary deposits, especially burned clays, may reveal impressions of textiles, cordage, and similar soft materials.[23] They have demonstrated that various forms of basketry and textiles were present in Gravettian sites in central Europe, and they say that Solutrean and other Upper Paleolithic peoples were producing rope, some of significant diameter.[24] To date, comparable evidence has not been recognized in any of the Solutrean sites or in our study area, but it is probably just a matter of time before it is. Fine fabric is not a prerequisite for boat sails, although it would be more effective than leather or plaited mats. Rope, however, is a necessity for a sailboat.

Even without direct evidence, examinations of micro-wear on stone and bone tools will undoubtedly reveal that some were used to make textiles, baskets, and the like. Although these sorts of studies have not been done in large numbers, those that have been attempted show that Solutrean people commonly worked a wide range of materials, including wood and hide. The presumption that complex and sophisticated fiber, wood, and skin technologies were ubiquitous in southwestern Europe by Solutrean times is important to our argument that Solutrean people were capable of producing waterproof clothing and constructing ocean-worthy watercraft. We have no doubt that all of the archaeological cultures we have included in this study had rich perishable artifact assemblages.

Some of the richest Solutrean sites have relatively well-preserved cultural deposits containing large quantities of animal bones, including delicate fish bones. It should be no surprise that bone artifacts are equally well represented. Among these are bone, ivory, and antler projectile points, foreshafts, needles, awls, knapping tools, shaft straighteners, atlatls (spear throwers), atlatl hooks, engravings, and ornaments.

Typological studies of bone points consider cross-section form and basic shape. The

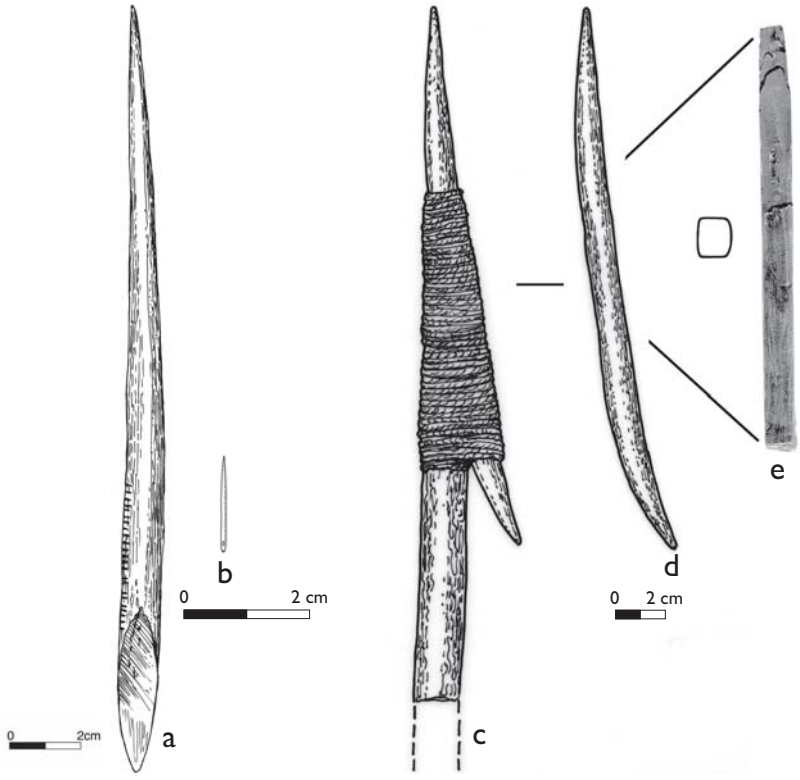

FIGURE 5.4.
Solutrean perishable artifacts: (a) bone projectile point (sagaie); (b) eyed bone needle; (c) self-barbed compound spear point with its assembled parts; (d) bi-pointed bone barb hafted to beveled spear shaft; (e) the flattened semi-rectangular center of the barb that provides a surface for hafting to the spear shaft.

most common type of bone point, called a sagaie, is a long, round to elliptical rod with a sharp pointed end and a frequently incised flat bevel end (figure 5.4a). It seems reasonable to infer that these bone points were hafted onto wooden shafts or foreshafts beveled to allow direct hafting. Other bone point forms are rare, including those with barbs. Few Solutrean bone points are ornamented, but simple engraved designs occasionally appear.

Sagaie were used throughout the Upper Paleolithic sequence but changed in type from their first appearance in the Aurignacian to the end of the Magdalenian. One of the major changes was an increased use of slotting on points by late Solutrean times at sites such as La Cueva de Amalda, suggesting that hunters favored bone projectile points with inset bladelets then.[25] However, small numbers of bladelets in earlier deposits with unslotted bone points imply that there were alternative uses for these sharp little stone bladelets. Self-barbed bone spear points occur in some Solutrean collections (figure 5.4c–e). These are slightly curved, sharply bipointed bone or antler rods or sagaies that were flattened and scored near the mid-section of the outside curve to create a hafting plane

for joining the point to the end of a shaft. This technique left both ends of the point exposed, the leading point for penetration and the trailing point as a barb to attach the prey securely to the weapon. A spear hafted in this manner was probably used for fishing or hunting in aquatic environments to retrieve the catch before it swam away or sank beneath the water.[26]

The earliest small, sharply pointed, eyed needles made of bone have been found in Solutrean deposits (figure 5.4b). These finely made tools approach the size of those used by modern tailors and indicate increased sophistication in sewing by Solutrean craftspeople. We have examined several of these specimens and note that they were perforated by gouging rather than drilling. The former technique produces slightly off-round holes that may have been more effective than round perforations for use with sinew fiber. Although smaller needles are not necessary for making tailored clothing, this innovation would have allowed the production of waterproof garments with seams made with overlapping stitching. It is unlikely that this was the beginning of fitted clothing manufacture, for earlier people had lived through equally inclement times and no doubt had well-designed weather-resistant outfits. As with any artifact type, absence from our current collections does not mean it hadn't been developed earlier.

Atlatls, or spear throwers, and atlatl hooks were made from reindeer antler, and some show extensive three-dimensional representational carving. The same is true of some of the perforated items thought to have served as spear shaft straighteners. Because of their elaborate carvings, they have been interpreted as status items, and nineteenth century French scholars referred to them as *bâtons de commandement* (staffs of command). It is also possible that along with signaling status, specially designed weapons were believed to possess greater power to attract game.

The introduction or development of bifacial thinning and pressure flaking techniques by Solutrean flintknappers demanded specialized flaking tools, most of which were probably fashioned from antler. Several examples of these artifacts have been recovered from Solutré. Although red deer antler, ibex horn, and even large bones could have served this purpose, reindeer antler is especially well suited for flaking tools because of its density. Furthermore, reindeer antlers were readily available in southwestern France. Excellent examples of worn-out and broken antler billets and pressure flakers found in trash middens attest to their use by Solutrean flintknappers.

FLAKED STONE TOOLS

There is a great deal of variation in the assemblages of flaked stone implements through both time and space during the Solutrean, and it would not surprise us if future underwater investigations revealed additional variation related to marine exploitation. We focus here on the French and northern Spanish materials and retain the French divisions of Lower, Middle, and Upper Solutrean.

Solutrean stone tools diverge in form from the immediately preceding assemblages,

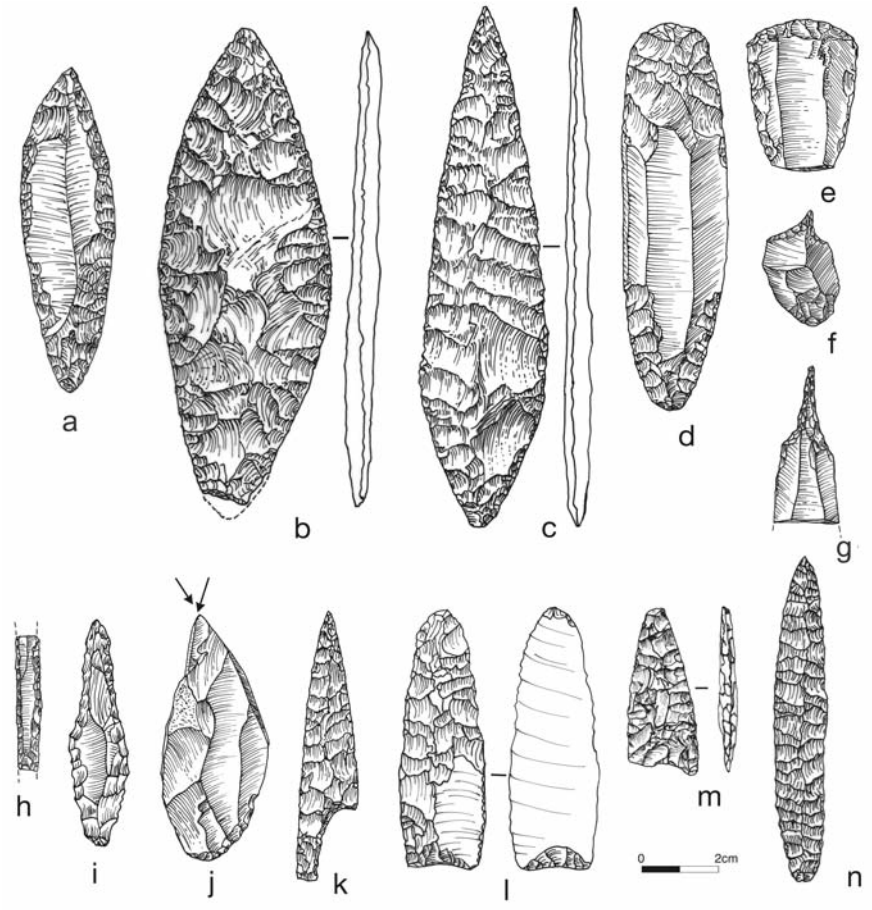

FIGURE 5.5.
Solutrean stone tools: (a) plane face point; (b–c) laurel leaf points or knives; (d) Solutrean scraper; (e) end scraper on blade; (f) graver; (g) perforator; (h) retouched bladelet; (i) bifacial borer; (j) burin, with arrows showing direction of burin spall removal; (k) shouldered point; (l–m) indented base points; (n) willow leaf point.

and in the earliest French levels they more closely resemble late Middle Paleolithic than Upper Paleolithic tools. Rather than abruptly backed, narrow points and knives, such as those made during the Gravettian, Solutrean knappers produced wider-pointed implements with flaking across the dorsal surface and occasional flaking, at both the tip and the base, on the ventral surface. These tools are called plane face points (figure 5.5a). In addition to the variations in proportions, the type and quality of the flaking separate Solutrean products from other Paleolithic artifacts. In the Middle Solutrean there seems to be an abrupt appearance of fully developed complex bifacial thinning, seen on what are called laurel leafs (figure 5.5b–c), and an increase in the use of blades and biface thinning flakes for tool blanks. During the French Upper Solutrean, innovations such as the eyed bone needle (figure 5.4b), shouldered points (figure 5.5k), and willow leaf (figure

5.5n) appear in the tool assemblages along with an increase in retouched bladelets (figure 5.5h). These developments seem to be most pronounced in the core area of the Dordogne of southwest France, less so in peripheral areas such as the Pyrenees. Laurel leafs continue to be a common component, and it is during this time that the oversize pieces found in caches were evidently introduced.

Generally speaking, then, through the course of the French Solutrean we see the introduction of fully bifacially thinned implements, the use of flat retouch (thinning), and end scrapers made on blades. Various other retouched implements occur, including end scrapers (figure 5.5d–e), strangulated blades (blades with opposing notches in their midsections), notches, biface flakes, perforators (figure 5.5g), bifacial borer (figure 5.5i), infrequent burins (figure 5.5j), and backed bladelets. Some of these tools are characteristic of Solutrean assemblages, including end scrapers with flaking across the dorsal face (figure 5.5d), end scrapers with corner spurs, and very fine single (figure 5.5f) and multi-tip gravers.

Much the same inventory is present in the northern Spanish sites, except that laurel leafs are rare while indented base points are more common. Some of this variation is likely due to the differences in stone available for flaking, as there is little large flint in northern Spain suitable for laurel leaf manufacture. The relative abundance of indented base points may be related to the increased hunting of sea mammals (see discussion below).

The northern Spanish Solutrean follows a different trajectory than the French Solutrean, with shouldered points found throughout the sequence (although not in every level), the introduction of indented base points (figure 5.5l–m), and a much lower blade component. Backed bladelets are also fairly common in later levels.

Of particular interest in Solutrean technology is the variety of formal projectile point forms. Plane face points (figure 5.6a) were most abundant during the Lower Solutrean but continued to be made throughout Solutrean times, especially in peripheral areas. Two formal projectile point styles were introduced during the Upper Solutrean in southwestern France: the willow leaf point (figure 5.6b) and the single-shouldered point (figure 5.6c). Both of these types were made from blades and are primarily unifacial (although fully bifacial forms exist), with only the tips and bases exhibiting flaking on the ventral surface. Well-controlled diagonal pressure flaking can often be seen on these points. The archaeologists Jean-Pierre Chadelle, Jean-Michel Geneste, and Hugues Plisson have conducted extensive experiments with and analyses of shouldered points and concluded that they were projectile points, possibly used to tip arrows.[27]

In northern Spain the Solutrean saw the introduction or development of indented base points (figure 5.6e) and single-shouldered points, the latter seemingly earlier than in inland France. Although the dating of the artifacts in many places is problematic, at La Riera Cave indented base points are found only in the lower levels.[28] Backed bladelets (figure 5.6d) increased in abundance through time and could have been used for the production of composite inset projectile points, such as those described in Beringia. A few slotted bone points have been found in the Upper Solutrean levels in northern Spanish sites, perhaps presaging their increased popularity in the following Magdalenian period. All of

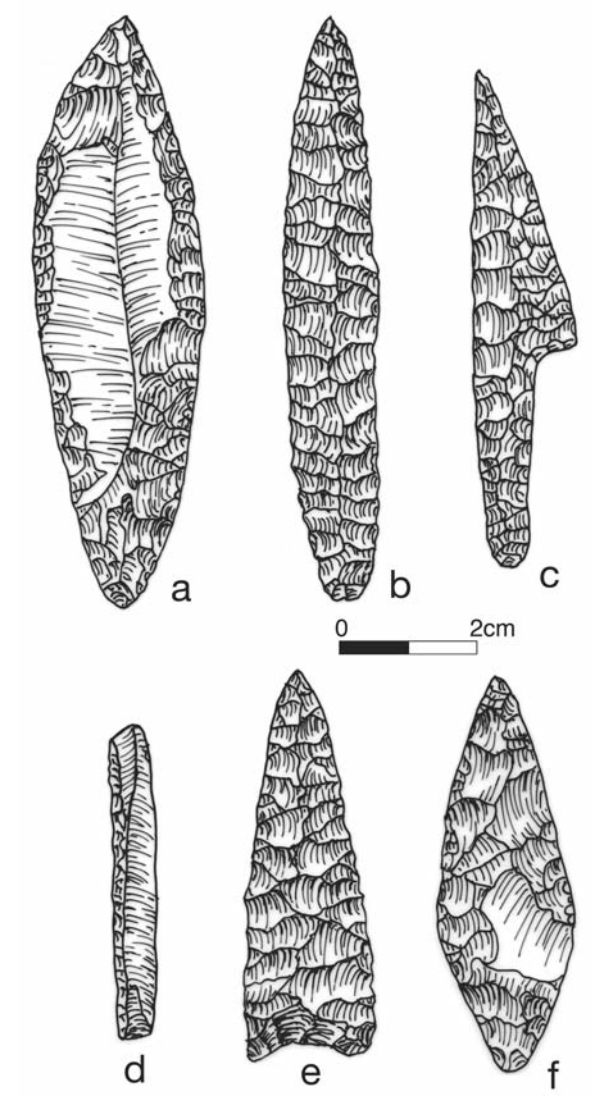

FIGURE 5.6.
Solutrean projectile points and inset blade for bone projectile point: (a) plane face point; (b) willow leaf point; (c) shouldered point; (d) backed blade, inset component of a slotted bone point common in late Solutrean sites; (e) indented base point; (f) small laurel leaf.

these innovations may indicate the increasing use of resources along the coast of Spain. We can only wonder if there is similar evidence of Solutrean coastal site use under the sea off the current French coast.

Exquisitely thinned bipointed bifaces, known as laurel leafs, are the most distinctive Solutrean artifact. These tools appear in a wide variety of sizes, ranging from just a few centimeters (figure 5.6f) to more than 50 centimeters in length. Most exhibit highly controlled specialized percussion thinning and pressure retouch. The scarcity of impact breaks and the presence of edge dulling on many of the medium to large specimens lead us to think that they served as knives rather than weapon tips; however, use-wear analysis is

FIGURE 5.7.
Casts of four of the fourteen large Solutrean laurel leaf bifaces from the Volgu Cache in France.

needed to verify this interpretation. Some are so large, thin, and delicately manufactured that it is hard to see how they could have served as tools.

Many students of the Solutrean have noted the extremes to which the bifacial thinning technology was taken. Some of the largest laurel leafs also have the smallest thickness-to-width ratios and are the most carefully made. Although we do not know of any use-wear analysis of these pieces, we think they may have been made for symbolic rather than utilitarian purposes. Philip Smith has also suggested that the eccentric forms that occasionally appear in the Solutrean had special, perhaps ritual uses.[29]

The other Solutrean tools remained much the same as in earlier times, but plane face points declined in abundance, possibly being supplanted by laurel leafs in France. That this was not the case in Spain may have more to do with the scarcity of large pieces of high-quality tool stone than with a lack of technological knowledge: local raw material is mainly medium-quality quartzite and small pieces of heavily fractured chert. The large majority of shouldered points and approximately half of the indented base points are essentially unifacial, with some flaking on the ventral surface at the tips and bases.

The archaeologist Anthony Sinclair suggests that Solutrean bifacial thinning had a symbolic function in its representation of the skills of precision, timing, and strategic planning, required for both the manufacture of these tools and the complex hunting techniques used by the Solutrean people.[30] Although complex bifacial flaking might not have been symbolic in all cultures that used it (e.g., Classic Maya), Sinclair's idea is intriguing in this particular situation.

Another hint that large, thin laurel leafs had special significance for the Solutrean people is their existence in caches. The best-known example is a group of fourteen extremely

large laurel leafs uncovered during canal construction in 1874 near Volgu, France (figure 5.7). The exceptional size and fragility of the Volgu bifaces imply specialized manufacture, possibly for an offering rather than normal daily use. Philip Smith describes other groups of large laurel leafs, many of which may have been caches. We have also heard of some twenty caches that are not reported in the literature available to us, including one in Portugal that the archaeologist João Zhilão told us about. Little can be inferred about the purposes of these caches, because all have been encountered accidentally during construction, tilling, or uncontrolled excavation. Some cached bifaces are clearly utilitarian, probably buried as a strategic storage of raw materials, whereas others were clearly buried under special circumstances. Caching is rare to nonexistent in other Old World Upper Paleolithic cultures.

LITHIC TECHNOLOGY

To better understand its similarities to early assemblages in North America through Clovis, we offer this examination of the details of Solutrean flaked stone technology.

Material Selection As one might expect, the Solutreans mainly used stone from their immediate area, yet their focus on exotic raw materials has often been noted. Even in northern Spain, where access to exotic stones appears to be limited, several Solutrean occupations at La Riera Cave contained many artifacts made of non-local raw materials. At Laugerie Haute in the Vézère Valley in France, where high-quality black and brown flint is abundant, a relatively large proportion of the Solutrean bifaces were made from nonlocal chalcedony and multicolored banded flints from the Bergerac area, as well as from jasper, quartz crystal, and even obsidian. The combination, unusual for the Paleolithic assemblages in the region, of these exotic materials is also present in southern Spain and Portugal. We have been told more than once that when archaeologists come across exotic chalcedony or quartz crystal Paleolithic artifacts, they can be sure that the tools will turn out to be Solutrean.

There are known sources of high-quality flint, such as the Upper Turonian flint at Les Maitreaux, that Solutrean knappers used to produce biface blanks. A Solutrean biface manufacturing site has also been discovered near Bergerac, which may be the source of the material for the many flint bifaces at Laugerie Haute. Otherwise knappers mainly used a high-quality local black flint. Although both of these locations fall within the known distribution of Solutrean sites, no major occupations have been found in their vicinity. It is clear that Solutrean knappers traveled significant distances to obtain preferred materials, especially for making laurel leafs.

Heat Treatment Another aspect of Solutrean technology was the intentional heat treatment of stone to improve its flaking quality. François Bordes and later Mike Collins presented convincing examples of this on some of the Laugerie Haute artifacts, and Marc

Tiffagom has shown that it was a common practice in the eastern Spanish Mediterranean and Portuguese Solutrean.[31] Using the strict standards applied by Collins, we thought the frequency of heat treatment was fairly low in southwestern France.[32] However, we recently re-examined a large sample of laurel leaf fragments from the sites of Laugerie Haute and Fourneau-du-Diable, which indicated that intentional heat treatment was indeed fairly common, perhaps in as many as 30 percent of cases, at least in southwestern France. The only way to determine the precise proportion of heat treatment would be to make a detailed analysis of large numbers of biface flakes and preforms broken in the early and middle phases of manufacture from completely collected deposits. Unfortunately, such pieces were not usually saved from the majority of Solutrean excavations. Yet all flaked stone items have been recovered from the Solutrean manufacturing site of Les Maitreaux, and there is no evidence of heat treatment there. This doesn't necessarily indicate that it wasn't used in the Solutrean—just that it may not have been part of the technology at that source location. This could have been the case because the flint there was fine enough without treatment or because the unfinished bifaces from that site were treated elsewhere.

Blades Like other Upper Paleolithic people, Solutrean flintknappers made large blades. We have identified at lease three different technologies, resulting in three different core types. It is unclear if all three methods were in use at the same time or if they form a succession through time. At Les Maitreaux the dominant approach was similar to that of the earlier Gravettian: two opposed platforms with blades struck from both ends toward the middle, resulting in what are known as bidirectional cores (figure 5.8a). The main product of this technology seems to have been straight blade blanks to be made into shouldered points. The second approach used a single primary platform with a single blade-making surface (figure 5.8b). Flakes and occasionally blades were struck from the opposite end, mainly to maintain the core surface or correct flaking errors rather than for the production of usable blades. The main objective of this technology was the production of not necessarily straight blade blanks for a wide range of tools. This approach resulted in wedge-shaped cores. The third approach had a single platform from which most blades were struck, but they were removed from the entire circumference of the core, giving it a conical shape (figure 5.8c).

In all three technologies great attention was paid to the production of each blade. Frequently the whole core platform was removed, creating core tablet flakes. Individual platforms were carefully adjusted by flaking and grinding on the striking surface and the adjacent ridges. The resulting blade platforms were usually bifacial and nipple-shaped. Although the archaeologist John Whittaker has suggested that indirect percussion was employed, we think the technique was direct percussion, with either a soft hammerstone or a billet of antler or wood.[33]

Unlike other Upper Paleolithic blade-making technologies, which began with fully bifacial precores, Solutrean technology started with knappers either taking advantage of natural ridges or making precores from medium to large pieces of flint. Frequently they

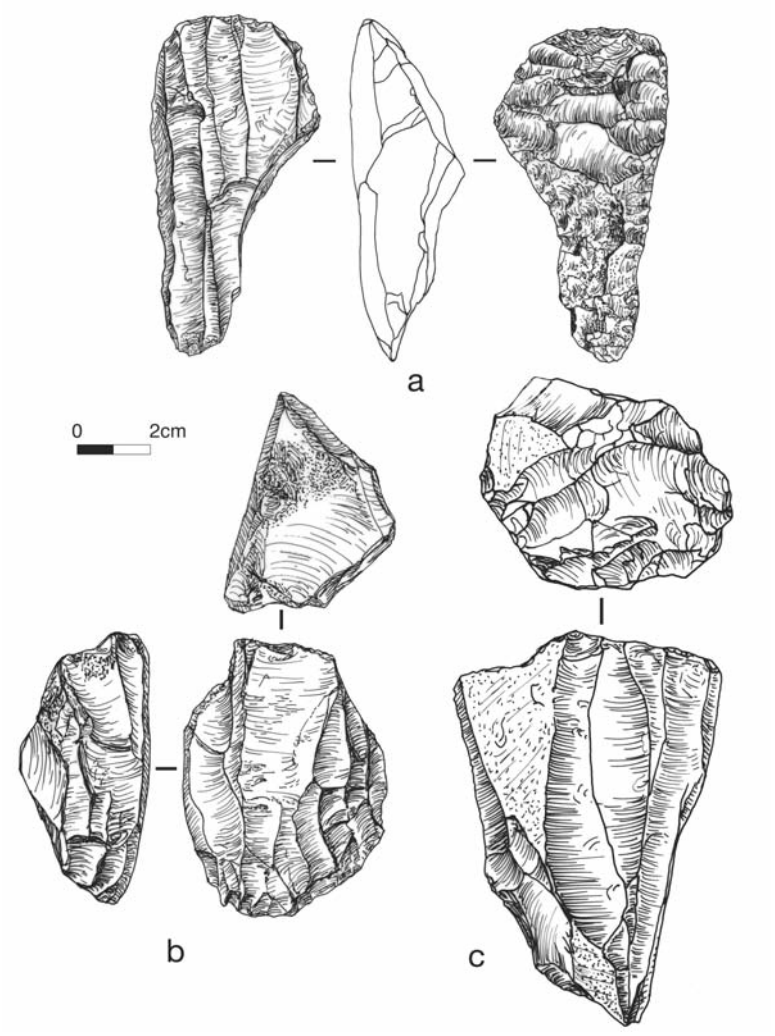

FIGURE 5.8.
Solutrean blade core types: (a) obverse, reverse, and section of a bidirectional core; (b) obverse, reverse, and top view of a wedge-shaped core; (c) face and top view of a conical core.

bifacially flaked a single ridge at slightly less than a right angle to a natural or prepared platform surface. For single-direction cores they often bifacially flaked the end opposite the platform, commonly perpendicular to the intended flaking surface, to produce a sharp angle. After striking an initial, crested blade (a series of alternating flake scars that form a dorsal ridge), removing much of or the entire bifacial ridge, they readjusted the platform, re-established the flaking surface projection (by removing corner blades, flaking laterally, or both), and removed another center blade. This process continued until either the core became too small or a major flaking mistake was made. Occasionally blades and flakes were struck from the bottom of the core, but this was done to correct mistakes rather

than as a standard blade-making strategy. The same basic procedure was followed for the opposed platform cores, except that blade making occurred from both ends, and cores tended to be abandoned sooner, when they became unsuitable for the production of shouldered point blanks. On these cores it is usually evident that one platform was preferred over the other, and most of the desired blade blanks were obtained from it.

Although this bidirectional, opposed platform process was generally similar to the earlier and contemporaneous Gravettian and later Magdalenian blade-making technologies, there is one significant difference: exhausted Gravettian and Magdalenian blade cores usually retain a portion of a bifacially flaked ridge on the back, opposite the primary flaking face; Solutrean cores, by contrast, usually have flat backs, either a remnant of the natural nodule surface or the result of flake scars originating from the sides. This distinction may seem minor and may have made little difference in production efficiency, but it does indicate a significantly different approach to core surface maintenance. The devil is in the details, and even such a small variation may have had cultural or traditional significance.

Noninvasive unifacial retouch of flakes and blades produced scrapers, gravers, backed tools, and other implements, as we see in other Paleolithic times. In addition to the usual types of percussion retouch, "flat retouch" was used to form some tools. In this process, retouch flakes invaded the surface of the blank to the extent that they shaped the entire contour of the piece, not just the edge. Normally, we would consider this shaping or thinning rather than retouch, as it was done to shape the piece rather than produce a tool edge.

Bifacial Flaking In Solutrean times there was much less emphasis on blade blanks and more inclusion of flakes as blanks than is seen in antecedent technologies. Flakes were frequently used unmodified as tools and as blanks for such implements as backed knives, side scrapers, and gravers. Most flake blanks probably came from laurel leaf manufacture, but there is an indication that they were also produced from bifacial disc-shaped cores.

Recent research on the Maitreaux assemblage has clearly shown how Solutrean laurel leafs were produced.[34] Our examination of hundreds of laurel leaf fragments from all phases of manufacture has not shown any significant departure from the steps taken there. Solutrean knappers selected large pieces of high-quality stone, then removed big flakes to create blanks or reduced entire pieces to bifaces. Blanks were usually flaked all the way around their circumference to produce a bifacial edge before thinning and regularizing began. Bifacing proceeded through to the finished product. The best evidence for intentional staging—planned intervals where flaking was either stopped and then re-initiated later or re-initiated in a different location—comes from Les Maitreaux, a knapping site to which initially edge-trimmed pieces were brought and from which nearly finished bifaces were taken. We have used this evidence plus some arbitrarily identified phases to see whether flaking decisions changed during the bifacing process.

We recognize four production phases after initial trimming (figure 5.9a–d): early, middle, late, and finished. These arbitrary phases do not have distinct boundaries, and we have not used width-to-thickness ratios to allocate pieces to them. To see if such characteristics

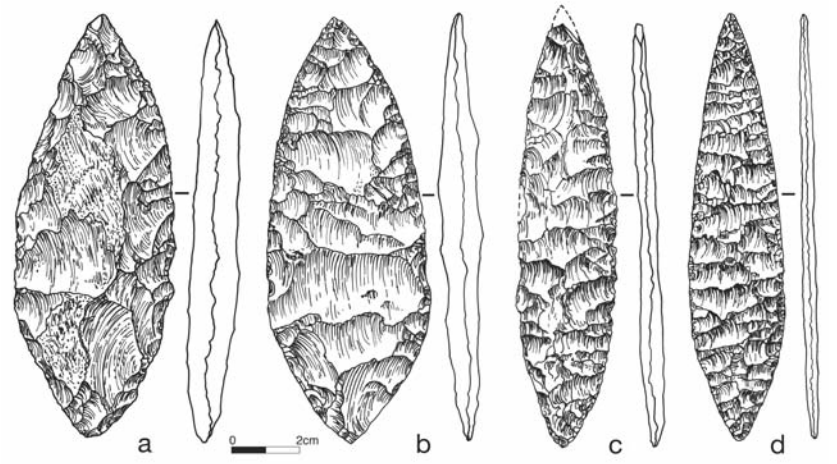

FIGURE 5.9.
Laurel leaf production phases: (a) early; (b) middle; (c) late; (d) finished.

as thinning method, pressure flaking, heat treatment, and width-to-thickness ratios changed during the sequence, we recorded a series of attributes of a large group of bifaces and biface fragments in the collections from Laugerie Haute and Fourneau-du-Diable, Solutrean sites in southwestern France. The results of this analysis allow us to describe the general biface flaking procedure.

Overshot flaking was applied during the early (26.5 percent of the pieces that exhibit overshot flake scars) and middle phases (28.1 percent) until a regular, flat, thin biface was made.[35] Flaking in the early phase focused on regularity of the edges and outline, with thinning beginning in earnest in the middle phase. Overshot flaking was applied in the late phase (23.9 percent) as the main thinning method. For finishing, Solutrean knappers switched to the diving flake method, although overshot was used all the way to the end (15.8 percent). Pressure flaking was used only for finishing, mainly for tip and base regularization, although some of the smaller pieces exhibit all-over pressure shaping and retouch. It is possible that some of these were flaked all over during reworking rather than initial production.

The following discussion details what effects each thinning choice had on bifaces. This is important, as we think decisions at this level can be used to demonstrate historical connections between technologies.

Overshot and diving flaking are both effective ways to thin a biface, and the preparation of platforms and the spacing of flake removals are critical aspects of both of these techniques. Platform preparation for overshot flaking is especially tricky because even a small variation in the angle or isolation of the platform or the place of fracture initiation will result in failure, frequently in the form of a diagonal (perverse) break. The angle of application and the amount of force applied are also crucial, as is the location of flake re-

moval in relation to the contours of the biface's surface. There must be enough mass immediately below the platform so that it does not shatter when struck, and the surface must have contours so that the flake tends to form with nearly parallel sides. A miscalculation of any of these features will result in either too much of the distal edge being removed (called a plunging fracture) or a deep hinge fracture, in which the flake terminates in a deep scoop taken out of the surface rather than an even taper (called feather termination). Interestingly, when possible, Solutrean knappers alternated sides on the same face during thinning. When successful, this is an effective way to achieve full facial coverage with the removal of only a few large flakes.

Diving flaking, by contrast, requires slightly less control and can be accomplished with less preparation. This is not to say that it is easy, but success may be achieved with a greater range of edge angles, platform placement, and angle and force of impact. The goal is to remove a flake that terminates in a shallow hinge fracture near the midline of the biface, and then to remove the hinge termination with flakes struck from the opposite margin. This technique is highly effective, barring major mistakes, but produces many small, relatively thin flakes. It also results in a high proportion of manufacture errors, especially when the flake struck to remove a hinge fracture itself terminates in a hinge short of the goal, leaving a stack near the middle of the biface. Once a stack is established, it is extremely difficult to remove from an otherwise thin biface.

Since most Solutrean laurel leafs are bipointed, basal thinning was accomplished from the sides rather than the base. Finishing was frequently done with pressure flaking, either by marginal retouch or, on the narrower pieces, by thinning, including overshot flaking. The last modification on many laurel leafs was a light to heavy grinding of the lower edges from the point of greatest width to the base.

The Solutrean biface thinning process was far and away more complex and difficult than any other method of flaking during the Upper Paleolithic. It also resulted in an overall greater use of raw material, related to the proportion of flakes used as tools (an exception being the large overshot flakes). Generally the technology may be thought wasteful if one considers only efficiency of tool manufacture. With limited supplies of exotic stones, it is curious that Solutrean people used them to make bifaces, unless they were for symbolic as well as practical purposes.[36]

Blades were used as blanks for various types of tools, including backed knives, denticulates (tools with a jagged-toothed edge), end scrapers, burins, and especially the distinctive single-shouldered points that are as diagnostic of Solutrean as laurel leafs. Shouldered points were made in different ways, some with indentations formed by abrupt retouch and minor ventral surface retouch at the tip and base. This style was most common in Spain. Alternatively, especially in southwestern France, shouldered points were frequently flaked by invasive pressure, leaving only small remnants of the original blank surfaces. Many shouldered points exhibit diagonal serial pressure flaking, which is especially effective for removing flake or blade ridges while only minimally narrowing the

A COMPLEX COINCIDENCE?

Fresh out of university, I spent the summer working in southwestern France with the noted French prehistorian and flintknapper François Bordes. This was where I first encountered beautiful and technically complex Upper Paleolithic artifacts. The highly sophisticated thinned bifaces, called laurel leafs because of their shape, were the greatest challenge for me to reproduce. Surprisingly, I found that I used the same approach to make laurel leafs as I used to make Clovis points. I thought this was curious but just a coincidence. It wasn't until years later that I began to think otherwise.

I am now involved in a project that studies the technology of the manufacture of laurel leafs. This project, directed by Thierry Aubry, has excavated a manufacturing site, Les Maitreaux, where the artifacts were preserved in their original discard locations. It is possible to see nearly complete flaking sequences in this assemblage, revealing specific decisions made by ancient knappers. The project has sponsored several experimental knapping sessions, each with a specific research question. A range of knappers with different skill levels have participated, including Thierry Aubry, Michel Lenoir, Serge Maury, Jacques Pelegrin, Marc Tiffagom, Bertrand Walter, and me. These experiments have been highly instructive and have opened up new levels of understanding of the complexity and difficulty of laurel leaf and blade manufacture. They have also led to various areas of interpretation in relation to site formation and the social implications of the archaeological record. It has been a great learning experience and a privilege to be part of this project. *Bruce*

piece. It also keeps pressure flakes from breaking off prematurely, especially on some of the lower-quality stones, such as quartzite.

Another style of projectile point occurs in many Vasco-Cantabrian assemblages. These are symmetrical with an indented base, and many exhibit diagonal pressure flaking on one face and little to no flaking on the other, except at the tip and in the basal indentation (figure 5.10a–b and f). These points are most frequently made of local quartzite and were probably made from straight, elongated flakes. Fully bifacially flaked indented base points are present in slightly smaller numbers (figure 5.10c–e and g–h). These bifacial points tend to be plano-convex (flat on one face and convex on the other) in cross section and occasionally have light basal lateral margin grinding and significant basal thinning (figure 5.10c and f), some of which would be identified as fluted if found in the Americas (figure 5.10g–h). Although indented base points were probably used in varying hunting situations, they are especially well designed for tipping harpoons and fishing spears.

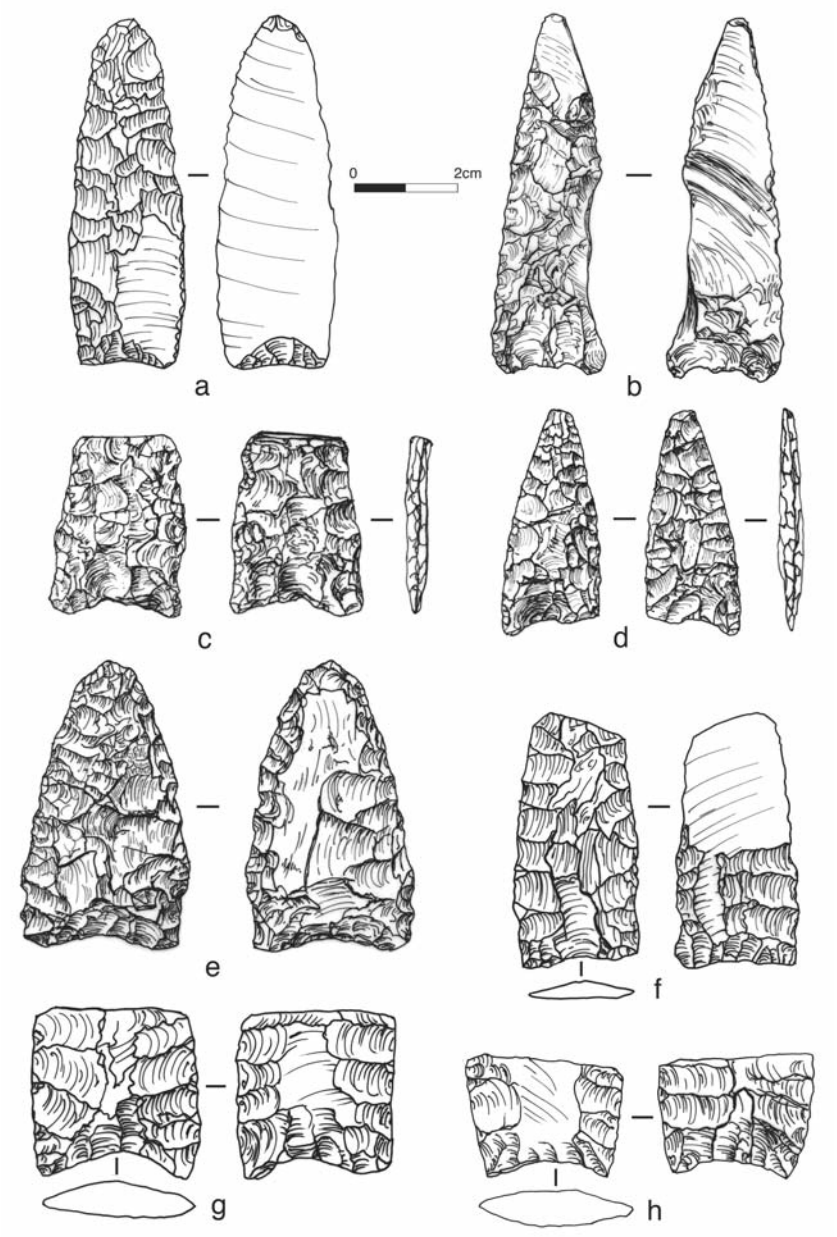

FIGURE 5.10.

Spanish Solutrean indented base points: (a–b) obverse and reverse of unifacially flaked points; (c–d) obverse, reverse, and side views of bifacially flaked points; (e) obverse and reverse of bifacially flaked points; (f) obverse, reverse, and cross-section of a partially flaked biface; (g–h) obverse, reverse, and cross-section of end-thinned (fluted) points.

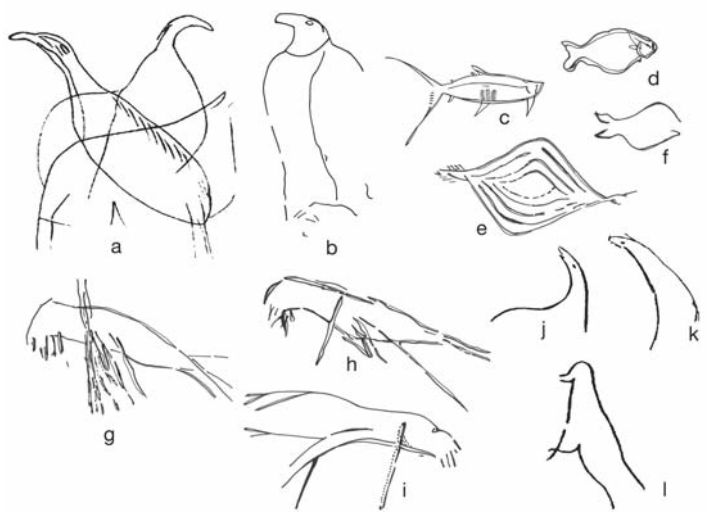

FIGURE 5.11.
Solutrean rock art figures of riverine and marine animals: (a–b) great auks; (c) salmon or tuna; (d–f) deepwater flatfish; (g) walrus or bearded seal caught in net; (h–i) walrus or bearded seals pierced by spears; (j–l) seals.

ARTISTIC EXPRESSION

Cave art became more common and more elaborate during the Solutrean, and both animal and abstract representations continued to develop. Large terrestrial animals such as horses and bison still dominated the subject matter, but there were now instances of great auks (figure 5.11a–b), river and marine fish (figure 5.11c–f), and other sea animals. The best examples of the last are walruses (figure 5.11g–i) and seals (figure 5.11j–l), but there is even a whale. These rare examples of marine animals are mainly in caves in northern Spain, but a cave found near Marseille in Mediterranean France is intriguing.[37] Underwater cave explorers found Cosquer Cave; its entrance is well below the modern shore, but the cave interior eventually rises above sea level. There is no direct evidence that Solutrean people created the paintings in this cave, which is just outside the known geographic range of the Solutrean. But radiocarbon dates place the latest paintings at around 18,000 RCYBP, and the entrance would have been exposed only when the sea was near its lowest level during the LGM—that is, in Solutrean times. Along with the usual array of large mammals are several images of what are clearly bearded seals or walruses with lines running into them that we agree depict spears (figure 5.11h–i). Some multiple lines may represent nets (figure 5.11g). This is significant for two reasons. First, it shows that people near the LGM sea were well aware of sea mammals and hunted them. Second, it is clear that sea mammals were hunted before the presumed introduction of toggling harpoons during the Magdalenian.[38]

Trout or salmon and flatfish are among the fish depicted in a number of Solutrean

cave sites. River fish bones have been found in Solutrean levels at La Riera. While it is possible that flatfish could have been procured from a beach, they are more indicative of deeper water, which may be evidence that Solutrean people fished from watercraft.

Depictions of three penguin-like birds represent the great auk, a large flightless bird that inhabited the ice edges of the North Atlantic until it was hunted to extinction during the early nineteenth century. This northern penguin could have been one of the favored prey of Paleolithic hunters, as it was for later seafaring people.

Portable art in the form of carved bone and antler items and incised pebbles is relatively abundant. Incised stones are especially common in eastern Spain, with designs about equally divided between animal and abstract geometric representations.[39]

HUMAN BURIAL

Another aspect of the Solutrean that sets it apart from earlier and later cultures in the area is the lack of intentional human burial. Although this conclusion could be the result of sampling bias, it is unlikely that investigators would have missed human remains in the extensive excavations of Solutrean deposits, such as those in Laugerie Haute, had they existed. Poor preservation can also be ruled out because animal remains, even down to delicate fish bones, are preserved in some Solutrean deposits, and human remains have been found both above and below Solutrean strata. Perhaps the dead were buried in the elusive open-air settlements or in isolated locations away from dwellings; perhaps they were placed aboveground on scaffolds or the like. The lack of human remains has hampered our ability to make standard physiological comparisons. Refined genetics techniques are now making progress in recovering ancient DNA, and future studies hold great promise for tracing human gene flow and identifying the biological relationships among members of prehistoric cultural groups, but they will not help elucidate Solutrean relationships until human remains are found in good Solutrean contexts.

ORIGINS AND THE END OF THE SOLUTREAN

It is abundantly clear that the Solutrean was highly variable through space and time. Individual sites and layers within sites exhibit major differences, although at least some of these can be explained by the use of different sampling and excavation techniques. There may also be other differences in assemblages that are related to changes in site use through time, as well as regional differences, possibly related to local stone resources. Still, the underlying flaked stone technology was remarkably consistent, with the singular focus on bifacial thinning setting it apart from other western European Upper Paleolithic archaeological cultures. It was not a simple technology; it included methods and techniques as complex as those employed much later during the Neolithic.

Bifacial flaking technology is not present in the earliest levels of the Solutrean, which is primarily identified by the introduction of flat (invasive) retouch and plane face points.

There are two opposing explanations for the technology's appearance: independent invention and diffusion. Philip Smith argues that the technology evolved in-place through time, whereas Jean-Philippe Rigaud and Jan Simek think the Solutrean had been fully developed elsewhere before appearing in Europe.[40] It is interesting that arguments over Clovis origins have revolved around the same issues.

In terms of technology and timing, there is a candidate for a Solutrean progenitor in the western Eurasian plain, known as the Streletskayan archaeological culture.[41] It falls before the LGM and includes sophisticated bifacial thinning technology and possibly pressure flaking and heat treating. The main objection to this theory is that there is little evidence of contemporaneous bifacial flaking between the two widely separated areas. This is only a problem, however, if we assume that diffusion had to occur through slow group-to-group interaction or large-scale migration. Ideas transferred over long distances by solitary individuals would be virtually impossible to detect in the archaeological record. What if a Streletskayan knapper ended up in southwestern Europe? We would not expect to be able to trace his journey, but such a person could be responsible for the introduction of a new technology.

Another possible antecedent for Solutrean bifacial flaking is in southern Britain, where thinned leaf-shaped bifaces (figure 5.12a–f) and plane face points have been recovered from sites more than 25,000 years old, although the specific context in each case is not clear.[42] It is possible that these artifacts date to the same time as those in France and Spain. Since the British Isles were attached to France during the LGM, it is easy to imagine a direct cultural connection.

On the basis of similar flaked stone technologies, the noted Paleolithic archaeologist Marcel Otte has proposed a North African origin for the southern Solutrean, even though this process would have required watercraft.[43] Yet if the Paleolithic archaeologist Curtis Runnels is correct about boats getting to Crete 130,000 years ago, an excursion across the Strait of Gibraltar 110,000 years later does not seem far-fetched.[44] Otte's theory is contrary to the usual notion that people move to milder climes in the face of a glacial advance. On the other hand, drought might have pushed people out of North Africa. And who are we to say that only the things that make sense to us could possibly have happened? If we take this approach it is difficult to see why the High Arctic would ever have been colonized, let alone during the LGM. In any case, it is encouraging that other researchers are using the same kinds of archaeological comparative criteria that we are.

Explanations for the origin of Solutrean biface technology that invoke independent invention are also well represented and often refer to the vague concept of adaptation to a changing environment. We find this less than compelling. To begin with, we have seen no good argument that there was a need for a new technology in the Solutrean environment. True, it was getting colder and drier, and hunting methods were probably changing, but this happened in many other places where biface technology was not developed. Additionally, the biface technology seems to precede the climate change. There

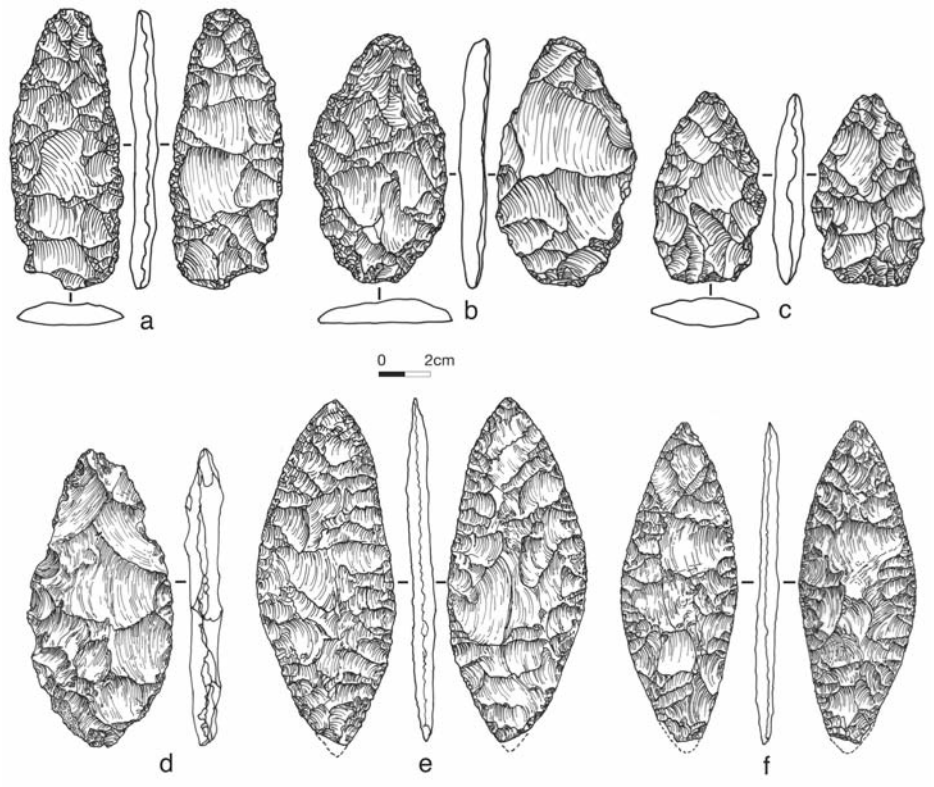

FIGURE 5.12.
British laurel leaf bifaces: (a–b) Soldier's Hole; (c) Kents' Cavern; (d) Inklingham; (e) Bury St. Edmunds; (f) Constantine Road.

are also examples of biface technology in almost every known climatic situation, from the Arctic to the full Tropics. In what way is bifacial technology superior and in what situations?

It will take a lot of work, with modern excavation methods, to sort out the origin of the Solutrean. Considering how long this archaeological culture has been studied, it is amazing how little we know about it, even in relation to earlier cultures in the same areas.

What happened to the Solutrean is equally puzzling. It was a well-established tradition with a reasonable spatial distribution. Its propensity for innovation would seem to have made it supremely adaptable to changing environmental situations. Yet the Solutrean was replaced relatively quickly throughout its territory by the Magdalenian, which appears to be a descendant of the earlier Gravettian tradition adjusted to take greater advantage of local and maritime resources in coastal areas. During the Magdalenian we see the most complex development of representational and portable art in southwestern France and northern Spain, seemingly a continuation of a long-lived tradition. Curiously, with the

exception of painted pebbles, the entire Upper Paleolithic rock art form vanished by about 12,000 years ago.

Perhaps the Solutrean did not disappear when we think it did. What might be found in the huge areas that now lie beneath the Bay of Biscay and the vast sand mantle of the Landes? We suggest that it is productive to consider the possibility that Solutrean people became more and more efficient in exploiting the rich sea margin resources until eventually their range expansion led them to a whole new world in the west.

PART 2

THE SOLUTREAN HYPOTHESIS

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QUANTITATIVE CULTURE COMPARISON

A critical but particularly difficult aspect of identifying the origin of a specific population is establishing the existence of historical relationships between it and other archaeological cultures. It is one thing to look at a group of artifacts and say they are alike, another to conclude that the likeness indicates that they are related. In Stone Age archaeology we get only minuscule glimpses of the human record, and we seldom have solid information about the more abstract, nonphysical characteristics—such as language, religious beliefs, mythology, music, philosophy, and symbolism—that we tend to use to define culture and ethnicity. Archaeologists are obliged to focus on tool forms, settlement patterns, subsistence strategies, and other features that exist within the natural world, and therefore some come to think that the natural environment is the major determining force in culture. We see both natural and social environments as having strong influences on the choices people make.

To understand and reconstruct broad historical connections between archaeological cultures, we have to clarify our assumptions. At what scale is it probable that two assemblages originated from a common base? When is it more likely that they are similar because there are a limited number of ways to make and use tools? In flaked stone technology (and elsewhere), the more generalized the level of similarity, the greater the chance of independent invention. Bifacial flaking is a basic approach to making usable tools and therefore very likely to have been independently developed by unrelated peoples. By contrast, the more complex the process and the greater the number of choices it entails, the less likely that it and even similar techniques would have been devised

independently in different places. For example, the fluting of projectile points seems to be limited in time and space. The technical and conceptual complexities are such that most researchers would agree that fluted projectile points are probably historically related.

It is appropriate at this point to ponder the meaning of independent invention. With only a few known exceptions, all people around the world at one time made stone tools. Archaeologists have established that stone flaking in Africa can be traced back at least 2.5 million years, and most of us presume that its invention was a single event from which all subsequent Stone Age technologies descended.[1] Only if it were shown that an ancient group had been isolated from sources of flakable stone for a long time and then started flaking when its members moved to an area with suitable raw material where there weren't already people to learn from would we consider the possibility that they reinvented the process.

When Upper Paleolithic blade-making people abandoned blades and produced flakes instead, was this an invention? Weren't their ancestors making flakes during the Middle Paleolithic? Was this then reinvention? What influence might mythology and history have had on the reintroduction of an ancient technology? Can the same questions be asked of specific specialized flaking techniques and methods?

Complex biface thinning appeared around 25,000 years ago in a small part of southwestern Europe and lasted for a relatively short time. How are we to determine whether this was a local invention, an import, or the resurgence of an ancestral technology? In the first instance we would have to identify a developmental sequence in the area. In the second we would have to find an earlier example that could have been brought there. In the third we would have to trace the history of the culture back through time and space. All of these approaches are extremely difficult to accomplish.

We presume that most needs for basic stone tools were the same worldwide and that they were met through intentional tool manufacture. To butcher an animal, people needed sharp, durable cutting edges. To turn an animal hide into usable leather, a scraping tool was required. We also presume that Stone Age peoples operated within established flaked stone technological traditions and that when the need arose for a new tool, their first avenue of experimentation would have been within the tradition they knew. Since different technologies can be used to produce equally functional tools, we see a plethora of different tool forms developed and used to accomplish the same tasks.

An excellent example of this is provided by comparing the projectile points at the sites of Amvrosievka, Ukraine, and Horner, Wyoming.[2] In both places many large bison were killed with stone projectile points and subsequently butchered with stone tools. At Amvrosievka the flaked stone projectile point tradition was inset blade: segments of small blades were glued into grooves cut along the sides of sharpened bone points. At Horner single points made in a bifacial tradition were hafted to a spear or dart. Even though they represented very different technological traditions, both weapon systems were effective.

MIND OVER MATTER

Just how strongly do people hang onto their traditional technology? One extreme case saw a new, unfit raw material bent to technology instead of the converse. During the Middle Paleolithic, between approximately 50,000 and 100,000 years ago, Europe, western Asia, and North Africa had a highly formalized and complex flake production technology now called Levallois. A core was created so that a single large flake, the same shape as the core, could be produced. These flakes were used as and modified into tools. The cores were then shaped into disks, with one face having a low, evenly convex face. After careful platform preparation, a flake was struck from this face that was also basically disk-shaped and had sharp edges all around, except for the platform. Once developed, this technology survived for millennia with a tenacity seldom seen elsewhere in the archaeological record.

At some point, people who used the Levallois technique occupied an area along the Middle Nile River. The only flakable stone there was small pebbles, less than 10 centimeters long, of fine-grained flint, with hard exterior surfaces and rounded sides and ends. It is extremely difficult to flake these pebbles within the Levallois tradition. To archaeologists and modern knappers, who expect the form and size of stone to influence technology, this would have been an ideal situation for a change in technique. Nevertheless, the Levallois tradition was so strong that the Middle Paleolithic knappers found a way to stick to it. First they knocked off both ends of the intractable pebbles, producing sharp opposing angles. Then they removed small bladelets from both ends, overlapping in the middle of the core. One end was used to prepare a typical Levallois faceted platform, from which was struck a Levallois flake.

In my experience this technique is a real challenge, and there is no indication that the bladelets were used. This is an absolutely amazing example of imposing a traditional technology on a difficult stone form. Once a Levallois knapper, always and only a Levallois knapper. *Bruce*

Once traditions have become established, how they changed and what contributed to the changes are important archaeological issues. One of the new theoretical orientations, called processual archaeology, bases many of its assumptions on adaptation as an explanation for change in the archaeological record.[3] This approach sees independent invention of the same technologies as a possible adaptive response to similar conditions. In flaked stone technology, adaptation could be expressed by the appearance of new tool types to exploit a changing or new environment or the adjustment of a technology to allow for

exploitation of new stone sources. But although we recognize the influence of changing stone sources on flaked stone technologies, we presume that people would have imposed their traditional technology on new situations before trying something altogether different. We also disagree with processual archaeology's underlying assumption that early people would have experimented to find the most effective and efficient way to make the tools they needed and accomplish necessary tasks. The archaeological record does not always support this "evolutionary technology" concept. Earlier technology may have been about achieving not perfection but simple adequacy.

How does all of this relate to our goal of identifying the origins of Clovis? We see Clovis flaked stone technology as distinctive, highly developed, and complex. This implies an antecedent with significant history; that is, Clovis is a "deep technology," the result of long-term development. It is unlikely that this complicated and effective approach to making stone tools was a rapid adaptation to particular local conditions. Its extraordinary utility is implied by its success in virtually every known ecological setting from the subarctic to the subtropics. This technology was imposed on diverse local environments and conditions rather than created by them.

If Clovis did not appear fully developed, where and in what technologies should we be looking for an antecedent? Based on what we know about flaked stone traditions at the end of the Last Glacial Maximum, we find three possibilities: Beringia, inset blade / thick biface; Eurasia, blade; and southwestern Europe, thinned biface / blade. In the present chapter we begin to evaluate these possibilities with quantitative comparisons of pre-Clovis, Clovis, Beringian, and European Upper Palaeolithic flaked stone technologies. Then, in chapter 7 we move to more qualitative comparisons of other aspects of these cultures: artifact form and function, cultural innovation, subsistence patterns, environmental settings, art, and specific human behaviors.

LIMITS AND METHODS OF COMPARISON

As we have pursued this study, the limitations of the available data have become abundantly clear. For the most part they follow from the small number of investigated sites and their poor state of preservation. With few exceptions only stone and the most durable of organic artifacts, such as bone tools, have survived, and then in only a few sites. This is true for not only whole time periods but whole regions. There is also great variation in the manner in which sites have been investigated and reported and their artifact assemblages analyzed. In many excavations before World War II, only the artifacts that were considered important or interesting were kept. Many "lesser" and broken pieces were discarded before being studied. It is difficult to determine from reports whether or not all artifacts were retained or what the selection criteria were. More than 85 percent of all French Solutrean sites were excavated before 1940, and few have detailed reports. The spoil heaps from these excavations are littered with flakes, bone scraps, and broken tools. Fortunately, by the late 1950s the work of François Bordes, Hallam Movius,

and André Leroi-Gourhan had transformed the methodology of Paleolithic archaeology in France, and the more recent Solutrean excavations, such as those by Lawrence Straus and his colleagues in northern Spain and Thierry Aubry and his colleagues in France, have been painstakingly documented, with all artifacts and many environmental samples retained.[4]

The sizes of samples are highly variable because of differential preservation, recovery method, and the size of the area excavated. Unfortunately, there seems to be an inverse relationship between the care of excavation and the size of the sample. For example, Straus and crew worked meticulously at La Riera, but by the time they got down to the lower Solutrean deposits they were able to excavate only five square meters. However, today's archaeology has so many analytical methods available that large samples can be an impediment to study. We want to know everything we can about what we recover, so we tend to recover less and analyze it more thoroughly. This approach has led to advances in understanding technology, ancient environments, and intra-site organization, but it has also meant that fewer sites and smaller areas have been investigated. This raises the thorny issue of how to realistically compare site assemblages consisting of tens of objects—including those collected in previous decades, when only portions of the artifacts were taken—with those having tens of thousands.

Another difficulty is our having to rely on secondary publications in situations where either the primary data was not published or we didn't have access to it. Some sites have been summarized in several books, with major discrepancies among the reports. These usually take the form of different numbers and types of artifacts being reported. Which do we use as our reference? Generally speaking we have relied on the most recent reports. Although these discrepancies do not alter the overall interpretations of the major archaeological culture reconstructions, they inhibit detailed inter-site comparisons. But we contend that even with all of these limitations, archaeologists must keep going back to the available materials and information. We may be able to apply new analysis techniques and tease more information out of the existing collections. This exercise also helps to identify gaps in our data.

Considering the types of archaeological data we have or can acquire through additional analyses, how do we make our comparisons? Does it make sense to compare an assemblage of a score of artifacts from a special-function site with a sample of thousands from a long-term habitation? The obvious answer is that it does not. Why not group the sites into classes and compare within those categories? The answer is once again sample size. When it is possible to identify sites with a similar function, there are often only a few in each category, and these frequently come from huge geographic areas and are of different ages.

With all of these problems, should we just give up and admit the task is impossible or fall back on our subjective feel for similarities? Obviously we should do neither. It is possible to find methods that allow comparisons to be made from which we can draw conclusions, albeit with many qualifiers. This is what we have chosen to do.

To achieve a more robust analytical comparison, we have combined assessments of typological and technological traits, because these are most likely to represent cultural norms across sites that may not include the whole range of activities of an archaeological culture. For example, it is easy enough to say that all the archaeological assemblages we are considering as possibly related to Clovis have flaked stone tools. Everybody agrees, though, that this is not enough similarity upon which to base an interpretation of historical relationship. However, archaeologists commonly compare artifact inventories in conjunction with time and space relationships to identify historical connections, such as Denali deriving from Dyuktai.

The next requirement for establishing the historical connections among sites or assemblages is identifying their relationships in time. For example, it may be possible to make a case for a historical connection between archaeological cultures in Siberia and Alaska, but if the Alaskan material is older than the Siberian, the obvious interpretation is that the culture originated in Alaska and spread into Siberia rather than the other way around. Many sites and assemblages have not been dated and are chronologically placed by their geological context or typological similarity to dated assemblages, some of which are themselves indirectly dated. It is not our purpose here to reevaluate the dating of all these sites and assemblages. The dates we use are the most current we could find in the published literature. We do not, however, include some that may be chronologically mixed or whose dating depends solely on possible similarities to other poorly dated assemblages. (See the appendix for table A.1, which shows the assemblages we use.) We also group dates into large categories, primarily indicating whether they are earlier than, contemporaneous with, or later than 13,000–14,000 years ago. Although our conclusions about historical relationships among archaeological cultures are based on what we know about their chronological nearness or distance, this is not our overriding criterion.

Physical closeness among sites or assemblages is commonly used by many researchers to make interpretations about possible historical connections, although this is also based on our individual assumptions about what physical connections were possible in the past. It is a function not just of distance but also of what the perceived difficulties of travel might have been. The land connection—not the distance—between Alaska and Siberia is the main argument for the current dominant paradigm of Beringia as the origin of people in the New World. Of course physical distance is an important consideration, but we contend that the best criterion for comparison is typological and technological similarity combined with dating, which informs us about the probability of physical connections. We think that New World origin issues have frequently been approached backward: an evaluation of likely routes of movement led to a theory, which archaeological information was then gathered to support.

Tool typology has been used for decades to define and compare archaeological cultures. A standard approach of many archaeologists is to determine tool type proportions within

site assemblages and then construct cumulative graphs. They then use correspondences and differences to evaluate relationships among the assemblages. Wide divergences are explained as the product of different archaeological cultures or indications of different site functions or both.

In this study we expand these comparisons by adding technological attributes. Our basic assumption is that there are different ways to make tools and different tools to serve the same purpose and that choices in different technological traditions distinguish archaeological cultures. In addition, we accept that early humans incorporated abstract concepts into the forms and designs of the tools they made. Some designs and even the process of manufacture itself may have had symbolic meaning or even ritual function. The less a particular tool attribute can be shown to be necessary to its physical use, the more likely this attribute was culturally rather than functionally determined. An example of this is corner versus side notching of projectile points: although both served the same function and were fit to purpose, they were produced in these different forms.

FLAKED STONE TECHNOLOGIES: DYNAMIC SYSTEMS ANALYSIS

Archaeological cultures with a high degree of similarity in the way their artifacts were made, as well as in the abstract and symbolic aspects of their artifacts' forms and other characteristics, are likely to have a common ancestor. James Adovasio has shown us how this fact can be graphically applied to textile analysis and interpretation, and the same is true for flaked stone.[5] It is possible to devise a hierarchical chart with the simplest attributes at the top and the more complex ones toward the bottom. Symbolic aspects of the artifact (e.g., design styles) add even more specificity. Correspondences at the top may be fortuitous, but as they continue down the chart the more likely they are to be historically related.

Since raw material type and initial fracturing are universal features of stone flaking, their similarities in different assemblages do not inform us about possible historical relationships except at the dawn of stone tool making. How materials were selected and manipulated, however, does have the potential to help us identify more recent historical relatedness. This approach is most informative when applied to complex manufacturing technologies, such as bifacial projectile point or blade and microblade production.

We have designed a simple dynamical systems analysis (DSA) diagram that illustrates where two technologies are the same and where they diverge. Flaked stone tool production requires a series of decisions among a number of possibilities. Each action modifies the object, and the following decisions have to take the former results into account. Flaked stone technology is a sequence of causes and effects. Since there are almost always viable options, the choices of action represent the technological framework in which the knapper operates.

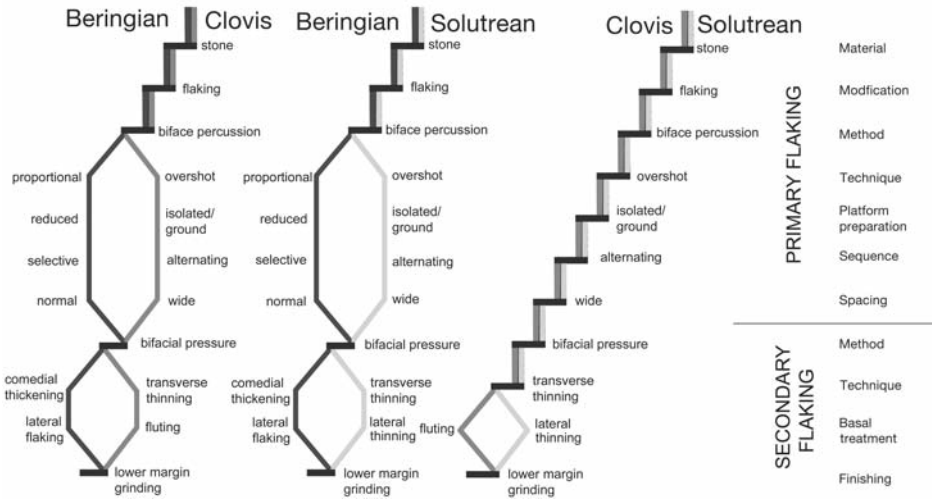

FIGURE 6.1.
Dynamic systems analysis chart of Beringian Sluiceway biface, Clovis point, and French Solutrean laurel leaf manufacturing sequences.

Since each manufacturing process begins with the simplest choices, correspondences between different technologies at these steps do not inform us about possible historical relationships. But as flaking continues, correspondence between two technologies is increasingly likely to be the result of a common ancestral technology. Along with sequencing, it is equally important to see where and how the processes diverge. The greater the number of divergences, the earlier they begin to occur in the sequence, and the more divergences there are in a sequence, the more likely the technologies are unrelated.

To illustrate this method we compared the manufacturing sequences of French Solutrean laurel leafs, Clovis points, and Beringian Sluiceway bifaces (one of the earliest kinds of Alaskan bifacial points). We examined identifiable flaking actions in the generalized production sequence from the beginning of the process to the finished piece.[6] The resulting DSA diagrams show distinct differences and similarities (figure 6.1).[7] The Solutrean and Clovis sequences are identical nearly to the end and diverge in only one attribute (basal treatment), whereas the Beringian sequence deviates early (with proportional shaping versus overshot thinning) from both the Solutrean and Clovis, maintains the divergence through several steps, corresponds for one trait (bifacial pressure flaking), diverges again, and finally corresponds for the last trait (lower margin grinding). These diagrams indicate that there is a much greater likelihood of a relationship between Clovis point and Solutrean laurel leaf technologies than between Sluiceway and laurel leaf or Sluiceway and Clovis technologies.

The similarities between Solutrean laurel leaf and Clovis point manufacture are remarkable, from the initial selection of raw material, which displays a preference for ex-

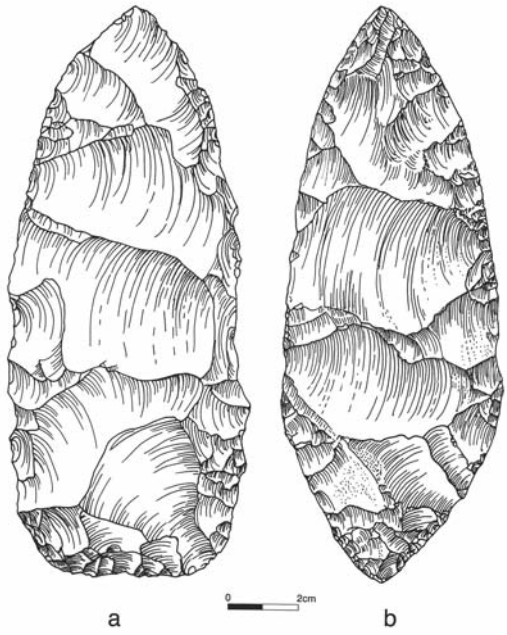

FIGURE 6.2.
Technological reduction comparison of middle phase manufacturing of bifaces showing overshot flake scars: (a) Clovis; (b) Solutrean.

otic stones, through the final edge treatment. Even the details of flaking are virtually identical (figure 6.2). Both technologies incorporated overshot flaking as the main method of biface thinning, especially during the early and middle stages (table 6.1). They also used the overshot technique to remove square edges. The spacing of the thinning flakes was wide, so only two to four needed to be removed from each face to produce a flat biface. In both systems, thinning flakes were frequently removed from the same face by alternating between edges. Even the preparation of flake platforms was the same. Both used isolated, projected, released ground platforms that were designed to be straight rather than convex.[8] Both even had platform grinding that extended from the area of contact on the flake platform to the adjacent flake removal surface. In North America, flakes with these platform attributes are diagnostic of Clovis, and this is true for Solutrean in Europe as well. Limited use of intentional heat treatment of the stone during the flaking process has also been proposed for both technologies.[9]

Finishing techniques were also virtually identical and included pressure thinning and shaping. The only real difference between the two technologies is that Solutrean laurel leafs exhibit a higher proportion of diving flake thinning than Clovis in the final phase of manufacture, whereas Clovis points were thinned from the base throughout the production process, ending with the distinctive basal flaking known as fluting. Both laurel leafs and Clovis points were finished with edge grinding from the greatest width to the base. Considering the time and space differences, this level of correspondence between technologies is amazing.

TABLE 6.1 Occurrence of Overshot Flaking on Bifaces

Clovis (counts)			
Phase	Face 1 only	Face 2 only	Both faces
Early (n=12)	8 (67%)	7 (58%)	5 (42%)
Middle (n=86)	47 (55%)	43 (50%)	29 (34%)
Late (n=27)	15 (56%)	7 (26%)	5 (19%)
Finished* (n=32)	15 (43%)	17 (53%)	9 (28%)
Solutrean (counts)			
Early (n=51)	15 (29%)	12 (24%)	8 (16%)
Middle (n=83)	30 (36%)	17 (21%)	6 (7%)
Late (n=54)	13 (24%)	13 (24%)	3 (6%)
Finished* (n=54)	9 (17%)	8 (15%)	3 (6%)

* Includes only complete finished points without evidence of reworking.

CLUSTER ANALYSIS

It is useful to determine possible historical relationships between individual artifact types, but how do we do the same with whole assemblages? Cluster analysis is a simple yet informative technique for finding natural groupings of objects on the basis of similarities and dissimilarities in their observed variables. No knowledge of group membership or possible number of natural clusters need be predetermined. Cluster analysis of flaked stone assemblages is less than ideal when applied to small collections or those with few attributes or characteristics. We fully recognize these limitations. Nevertheless, it's a more objective estimation than "they look alike to us."

As with any statistical method, the selection of which attributes to use influences cluster analysis. Because we think manufacturing technology is highly variable and most likely to reflect cultural choice, we have emphasized this aspect of the collections.

We tested out the cluster analysis method on North American fluted point assemblages, and the results gave us confidence that this is a viable approach to discovering relationships between these traditions and the nearly contemporaneous traditions in Beringia and Western Europe (see the appendix for the first, practice test). However, the large range of time periods, great geographic distance, and small number of sites in some areas required different criteria than were used for the fluted point sites.

Rather than include tool counts converted into proportions, we worked exclusively with the presence and absence of tool types. We also grouped sites and assemblages into major archaeological complexes. For the most part, we considered a type present if it had at least one unambiguous occurrence. For example, if there was a single good graver within the Late Dyuktai assemblages, we marked this type as present. It could certainly be argued that this was overly generous, but the sample sizes are so small that we feel one occurrence is significant.

Although the shaft wrench found at the Murray Springs Clovis site is unique and there is no direct evidence that this type of tool was widely used, almost everybody who has written about Clovis assemblages considers it a Clovis tool type. An ivory flaking tool called a billet, found at Blackwater Draw, is another single occurrence, but in this case we can be sure that it was a common tool type, because thousands of identifiably biface thinning flakes in Clovis sites were made with just such a tool.

As with the fluted point assemblages, for the most part we used the identifications of tool types as they have been published. The only area where we consistently deviated from this rule was in what we labeled bifaces, which were originally called preforms, knives, or just bifaces; however, we did not include bifacial microblade precores in this category. Where the illustrations or descriptions allowed, we made some reclassifications.

Cluster analysis allows certain attributes to be assigned more weight than others, so it would be possible to give more emphasis to common tool types or primary technologies. We have not pursued this, because we feel that the results we achieved without weighting different categories were sufficient and that emphasizing specific categories would probably have produced tighter clusters rather than different ones.

We did two separate analyses, one with stone tool type assemblages and another with technological traits. Appendix table A.2 lists the assemblages and tool type presence and absence assessments we used in the first analysis. Some of these assemblages contain bone, ivory, and antler tools, but their absence from many, most commonly because of poor preservation, influenced us not to include them.

Three distinct groupings emerge at the third level of clustering (figure 6.3). The first includes Pre-Clovis, Ushki/Early Dyuktai, Mesa/Sluiceway, Nenana, and Denali. This incorporates all of the Beringian assemblages and the very limited pre-Clovis sample. The second cluster includes all of the Solutrean assemblages, with the exception of Early French Solutrean, and the fluted point assemblages, including fluted point and Late Dyuktai. The final cluster contains three Upper Paleolithic European archaeological cultures that did not have biface technology: French Gravettian, French Magdalenian, and early French Solutrean.

For us the only surprises are the clustering of pre-Clovis with the Beringian assemblages and of Late Dyuktai with Solutrean and Clovis. Both may be attributed to small sample sizes. Pre-Clovis consists of just a few tool types from only two sites. By contrast, there are relatively huge collections from fluted point and western European Upper Paleolithic sites. It is also possible that the pre-Clovis sites clustered with the Beringian sites because they represent similar functions, or because pre-Clovis significantly contributed to Beringian technology, especially in eastern Beringia. This analysis does not take flaking technology into account, so we do not think it is the best method to investigate possible historical connections. Although most researchers consider them to be closely related, Late Dyuktai did not cluster with Denali. This is curious, as the site functions and sample sizes were similar, and it is a good example of how tool typology is not particularly indicative of technological traditions.

Our next analysis considered flaking technology, handled in much the same manner

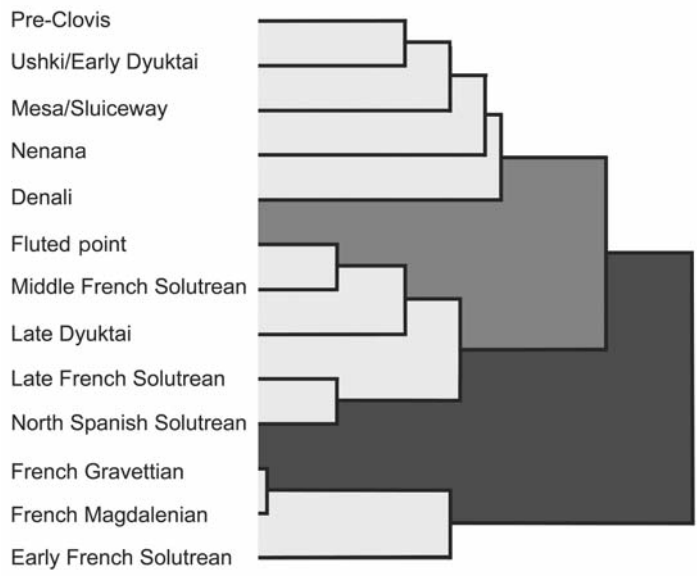

FIGURE 6.3.
Cluster analysis dendrogram of selected Beringian, Early Paleo-American, and Late Paleolithic European assemblages by tool type.

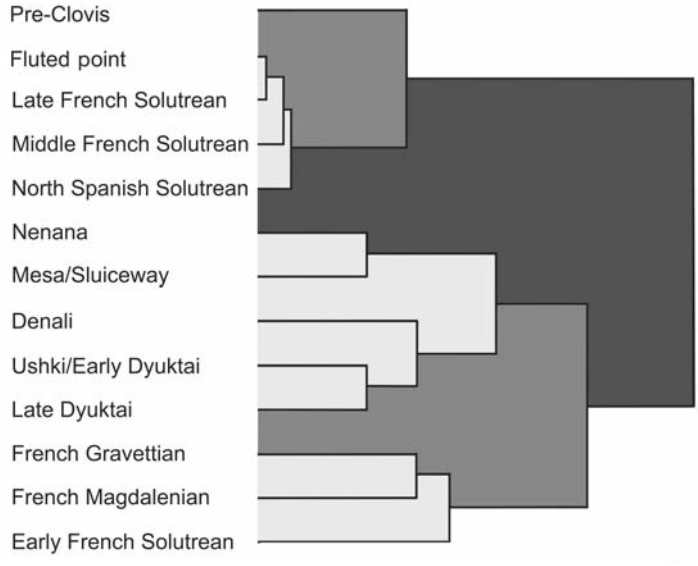

FIGURE 6.4.
Cluster analysis dendrogram of selected Beringian, Early Paleo-American, and Late Paleolithic European assemblages by technology.

as tool types: we noted presence and absence and did not weight any attributes. Here we looked at such technological traits as bifaces, microblades, and blades, as well as the technological details of each. We used the same collections, but the variables were obviously different, as shown in Appendix table A.3.

The cluster analysis results again produced three groupings at the third level, but now pre-Clovis clustered with the fluted point and Solutrean assemblages (except early French Solutrean), and Late Dyuktai clustered with Ushki/Early Dyuktai, Denali, Mesa/Sluiceway, and Nenana (figure 6.4). This analysis seems to indicate that small samples of artifacts can reveal the underlying technology even when tool type variability is low. The main distinguishing characteristics between these lithic manufacturing systems are blade/microblade and biface technologies, separating the non-bifacial-dominated Upper Paleolithic Eurasian and Asian from the Solutrean and American assemblages.

The distinction between weapons with single stone components (such as hafted Clovis points) and composite points (inset with multiple stone pieces) is also apparent. At lower cluster levels the non-microblade, eastern Beringian assemblages (Nenana and Mesa/Sluiceway) break away from the microblade assemblages (Denali and Dyuktai) in both eastern and western Beringia. Fluted point assemblages separate from the Solutrean at the next to lowest level, and we have to go to the final level before we see the separation of pre-Clovis from the fluted point and Solutrean assemblages. Even more significant, the assemblages that hang together the longest are fluted point and Solutrean.

In considering both cluster analyses, it is clear to us that there are three distinctly different traditions. One is present in the greater Beringian area concurrent with and immediately following Clovis times. Its few similarities with the fluted point tradition can be attributed to a Paleo-Indian penetration into northern Alaska and possibly Siberia after 13,000 years ago, rather than the other way around. The other two clusters are in southwestern Europe, one of which extends west to include continental North America. Even though the Upper Paleolithic cluster that includes the Gravettian, early French Solutrean, and Magdalenian occupies the same territory as the other Solutrean assemblages, these analyses show them to be distinctly different. Clustering also indicates that the Beringian assemblages have more in common with the Upper Paleolithic blade traditions than with the Solutrean and fluted point traditions, probably resulting from a common ancestral technology.

7

QUALITATIVE CULTURE COMPARISON

Although quantitative analyses and statistical manipulations are useful, a lot of what we infer relies on more subjective assessments and comparisons. This is frequently because we don't have the information required for more vigorous approaches. For better and for worse, the great need for large, long-term studies of the original collections leaves a lot of scope for future research. Since this work has yet to be done, the following observations are not based on detailed analyses, but we think they are nonetheless interesting. We have tried not to fall into the cherry-picking trap of considering only those items that exhibit the characteristics helpful to our theory. We look at not only tangible evidence, such as artifact forms and signs of the heat treatment of materials, but also less tangible evidence, such as artistic expression and behaviors like caching large bifaces. We also consider cases in which a lack of evidence (about burial practices, for instance) might be meaningful.

STONE TOOLS AND TECHNOLOGY

END SCRAPERS

End scrapers are common in Upper Paleolithic, Paleo-Indian, and many other archaeological assemblages around the world. In fact, they were probably the most common type of formal stone tool in Late Stone Age hunting and gathering cultures. Generally speaking, they are highly standardized, and the shape of their working edge is greatly influenced by its function, which is usually hide working. Nevertheless, their forms and method of manufacture do vary among archaeological cultures.

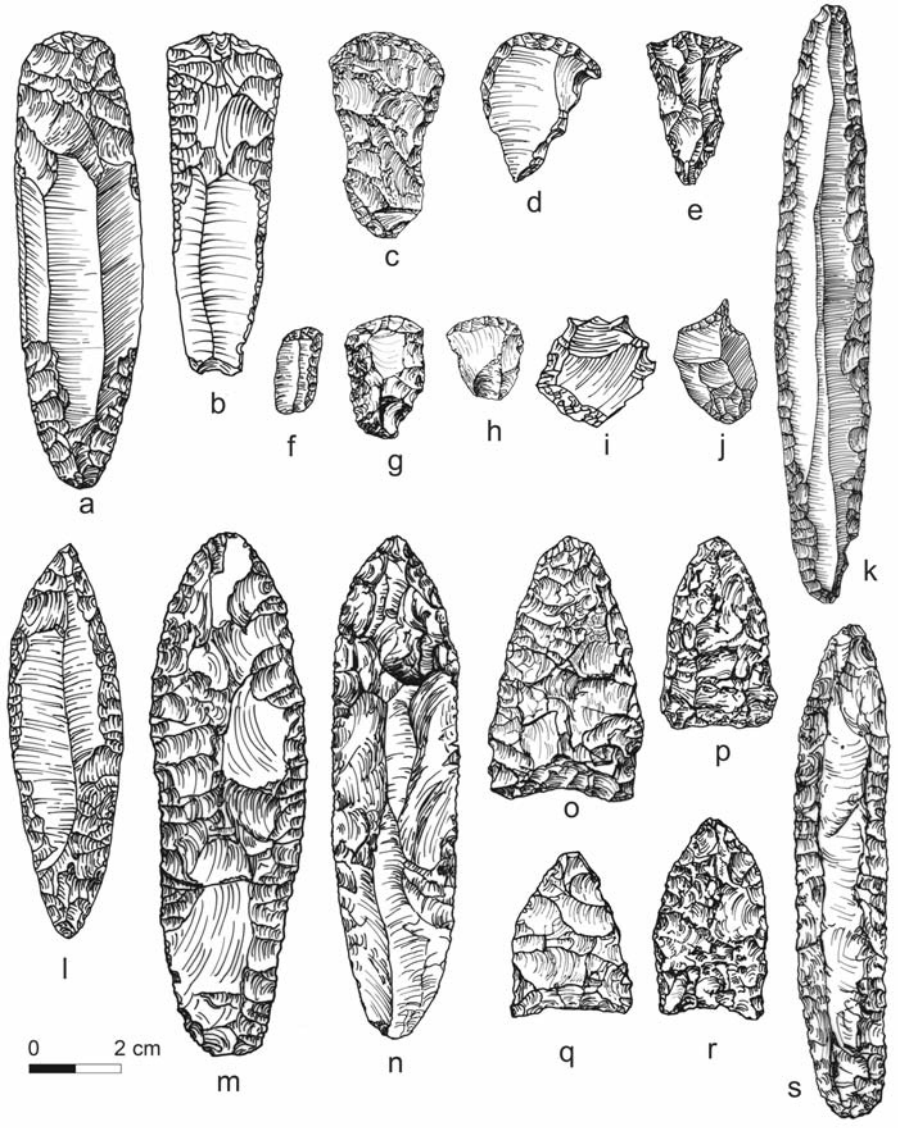

FIGURE 7.1.

Comparisons of Solutrean, pre-Clovis, and Clovis lithic tools: (a) Solutrean end scraper made on a blade; (b) Clovis end scraper made on a blade; (c) Southeast Early Paleo-American (proto-Clovis) end scraper made on a blade; (d) Solutrean spurred end scraper; (e) Clovis spurred end scraper; (f) Solutrean microscraper; (g) Early Southeast proto-Clovis microscraper; (h) Clovis microscraper; (i) Clovis graver; (j) Solutrean graver; (k) Solutrean retouched blade; (l) Solutrean plane face point; (m) Southeast Early proto-Clovis plane face point from the Johnson site; (n) Southeast Early Paleo-American plane face point from Florida; (o) Solutrean indented base point; (p–r) Early Mid-Atlantic Paleo-American indented base points; (s) Early Southeast Proto-Clovis steeply retouched blades.

Nearly all the Paleolithic assemblages we have examined have end scrapers, made on either flakes or blades, and for the most part their forms are not distinctive. Those produced by unifacial percussion or pressure flaking that extends up over much of the dorsal surface of the scraper blank are an exception (figure 7.1a–c). This flaking style is present in only French Solutrean and the earliest North American Paleo-Indian assemblages. In fact, these are called Solutrean scrapers in the French tool typology, which considers them, like laurel leafs, a diagnostic type.

Does this mean that the same type of end scraper is a normal product of the general flaking technology, especially pressure flaking, and not really distinctive? This is unlikely, because many Beringian and post-Clovis flaking technologies include both biface manufacture and pressure flaking but lack this form of end scraper. Thus, it appears that this trait may be the result of technological continuity.

The second distinctive type of end scraper has a different style rather than a different flaking method. It is called spurred because it exhibits small well made sharp points on one or both corners of the working edge (figure 7.1d–e). These spurs are the product of intentional pressure flaking and should not be confused with scrapers that have incidental points on their corners. Some of the intentional spurs are fine enough to be used as gravers, but their purpose is unknown. These scrapers were frequently made on biface reduction flakes.

Spurred scrapers are characteristic of most Paleo-Indian and Solutrean tool kits but are rare to nonexistent in Beringian and other Upper Paleolithic assemblages. They do occur in the Mesa lanceolate point assemblage, which was introduced from the south and is not part of the western Beringian technology, making it unsurprising that the Mesa tool kit would include this scraper form. Are spurred scrapers another link between Solutrean and Clovis? We think they may be.

A third distinctive form is the microscraper, which is found in Solutrean (figure 7.1f), pre-Clovis (figure 7.1g), and Clovis (figure 7.1h) assemblages. These are basically the same as other end scrapers in proportions and configuration, but they are less than 3 centimeters long. They seem to have been intentionally made small and not the result of resharpening. In the French Upper Paleolithic these forms first appear in Solutrean assemblages, and they are absent from Beringian assemblages.[1]

GRAVERS

Gravers have very small, sharp projections flaked on a thin flake or blade (figure 7.1i–j). It is unclear what they were used for. Gravers with single and multiple projections are present in Solutrean and Clovis assemblages, but they are absent from the Dyuktai/Denali collections. Like the earliest spurred end scrapers, fine point gravers first appear in Beringia at the Mesa Site and are also associated with lanceolate and fluted projectile points that likely had their origins in the south.

PLANE FACE POINTS

A hallmark of early Solutrean assemblages is the plane face point (figure 7.1l–n). These are primarily unifacial and are found in varying proportions throughout Solutrean times. They also appear in the New World. One was found at the Johnson Site in Tennessee (figure 7.1m). This artifact was seemingly made from a blade and produced with intent, and it displays the typical manufacture technology of Solutrean plane face points. Another specimen was found near Rum Island in the Santa Fe River, Florida (figure 7.1n). It was not recovered from an in situ context, but Clovis and pre-Clovis artifacts, also not in situ, were in its immediate vicinity. This point was also made on a blade (blades are not found in post-Clovis assemblages in Florida) and conforms to Solutrean technology.

INDENTED BASE POINTS

Another important artifact type is the indented base point from northern Spain, some southern French Solutrean sites, and pre-Clovis sites in eastern North America. We noted in chapter 5 that the Spanish Solutrean points were made with a distinct technology that was probably strongly influenced by the unavailability of easily flakable stone. These are relatively small points, some of which are unifacial but many of which are fully bifacial (figures 5.10 and 7.10). Even the points that are considered unifacial are often partially bifacial, especially at the tip and base. Indented base points from pre-Clovis contexts are usually fully bifacial, although some are partially unifacial. Like the Spanish Solutrean points, the earliest pre-Clovis points were made with a combination of percussion and pressure flaking (figure 7.1p–r). Many of the Spanish Solutrean and pre-Clovis indented base points are similar in size, form, and manufacturing technology. It should not escape our attention that Clovis points have indented bases. In addition, while the incidence of unifacial Clovis points is low, they do exist, and although some were expedient forms, hastily made on flakes, others, like Solutrean examples, are well made (figure 2.6b–c, i).

As our pre-Clovis point sample continues to expand, we are beginning to see developmental trends in sizes and technologies. Spanish Solutrean (figure 5.10) and Cactus Hill/Miller points are small and subtriangular (figures 4.2, 4.3a–b, and 4.4d). The later Jefferson Island, Page-Ladson, and Suwannee point styles range from small to larger sizes more typical of Clovis forms (figure 4.10a–c and m–p). Although fluting occurred only in the Western Hemisphere, some Spanish Solutrean points have significant basal thinning that may presage fluting technology (figure 5.10f–h). In addition, the first incidence of an end-thinning flute scar on an unfinished point preform is seen in the 21,000-year-old Miles Point pre-Clovis assemblage (figure 4.4e). By the time of the Johnson Site occupation, flintknappers were experimenting with significant basal thinning on nearly completed bifaces (figure 4.11,b,d and f). It isn't possible to get an idea of success rates from this assemblage—completed points would have been removed from it after manufacture—

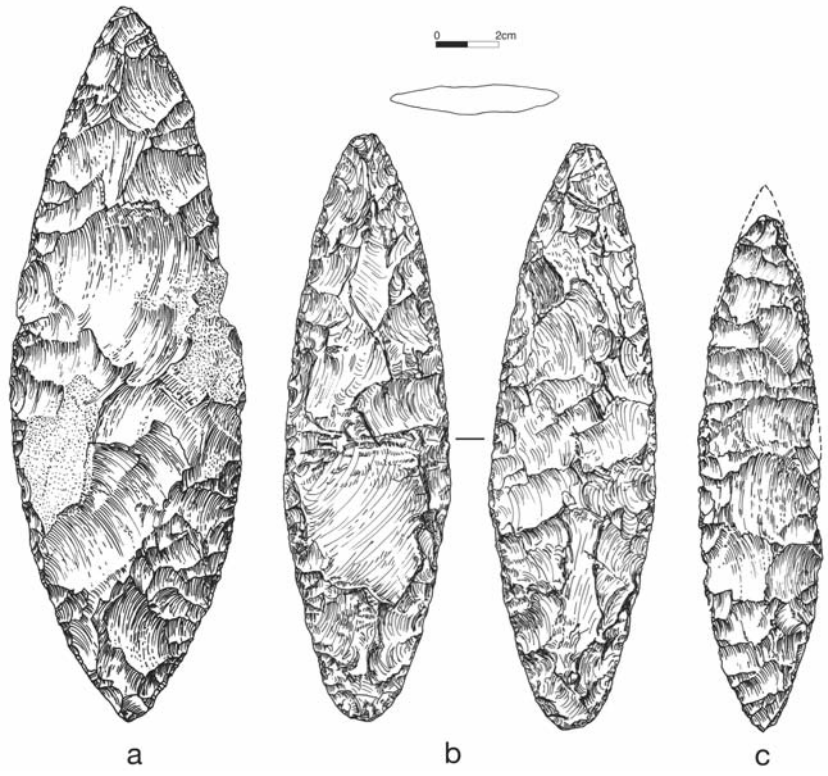

FIGURE 7.2.
Laurel leaf bifaces: (a) Fourneau-du-Diable southwest France; (b) Cinmar Site, obverse, reverse, and cross section; (c) Aquitaine region of southwest France.

but there were clearly a lot of errors, as one would expect in the development of this risky flaking method. It appears that Solutrean flintknappers in northern Spain developed the technique of basally thinning projectile points, perhaps only to remove the center ridge of a blade. However, the advantage of a concave-based point is for ease of hafting to a spear or harpoon. The bottom line is that there is a chronological, typological, and technological continuum from the earliest indented base points in southern France and northern Spain to the inception of fluting technology in eastern North America.

LAUREL LEAF BIFACES

Thin leaf-shaped bifaces with well-controlled percussion thinning flake scars on both faces, common in many Solutrean assemblages, have been found in the Mid-Atlantic region of North America. The geologic context of the North American specimens indicates that they overlap in time with their Solutrean counterparts. Both Solutrean and early North American laurel leafs have non-invasive percussion retouch along the distal margins, which seems to be a by-product of resharpening and, along with edge dulling and the

scarcity of impact breaks on many of the medium to large specimens, leads us to think that they served as knives. Pressure burin fractures—the loss of flakes from the tip of a blade pressed against a resilient object such as tight skin or bone—common on the tips of many Solutrean laurel leafs are also indicative of knife use (figure 7.2c).

BLADE TECHNOLOGY

We have focused our attention on bifacial technologies for our comparisons of flaked stone assemblages, but the manufacture of other specialized flake and blade forms can be equally complex and variable. With the exception of Mike Collins's discussion of Clovis blade technology and detailed analyses of some of the non-Solutrean Upper Paleolithic blade and microblade technologies in Eurasia, relatively little attention has been paid to this aspect of flaked stone technology.[2]

Although there are almost unlimited ways to produce blades, bladelets, and microblades, two basic approaches were used in the assemblages in this study. The first was production from natural unmodified stones or flakes, with little or no core preshaping. This is typical of bladelet technologies, whose process is much like that of generalized flake production except that the removals are spaced and sequenced so that many of the flakes are elongated (at least twice as long as wide). This approach was used in the northern Spanish Solutrean sites; the pre-Clovis sites of Cactus Hill, Miles Point, Meadowcroft, and Oyster Cove; some Clovis sites; and some Beringian assemblages. A lack of high-quality or large enough raw material may in some cases have heavily favored the selection of this method: expedient bladelet production is common where coarse quartzite and other grainy-textured pebbles and cobbles make up the majority of available materials. It is of course difficult to determine whether the technology was a response to the raw material or the stone was selected because it suited a traditional bladelet technology.

Bladelets and microblade technologies found in the Solutrean, pre-Clovis, Clovis, and various Beringian technologies were frequently created with the same form as a blade wedge-shaped core, but smaller (figure 7.3a–c).[3] In some cases, especially in northern Spain and on the East Coast in North America, the production of bladelets was heavily influenced by the predominant availability of mainly poor-to-medium-quality small raw material. There are also bladelet cores in Clovis and Solutrean sites where large high-quality raw material was available, but these often seem to be the result of large blade core reduction rather than a separate bladelet technology.

The second basic approach to the production of blades and microblades is to shape the raw material into a suitable form, or precore, before blade production begins. Two different strategies are visible in our assemblages: preparation of a single core face for blade removal and complete precore shaping by the production of a thick biface (see chapter 1 for a discussion of these techniques). The latter is widespread in the early and late Upper Paleolithic assemblages in southwestern Europe. Most cores from these technologies end up with a remnant bifacial ridge on the back, opposite the main blade-pro-

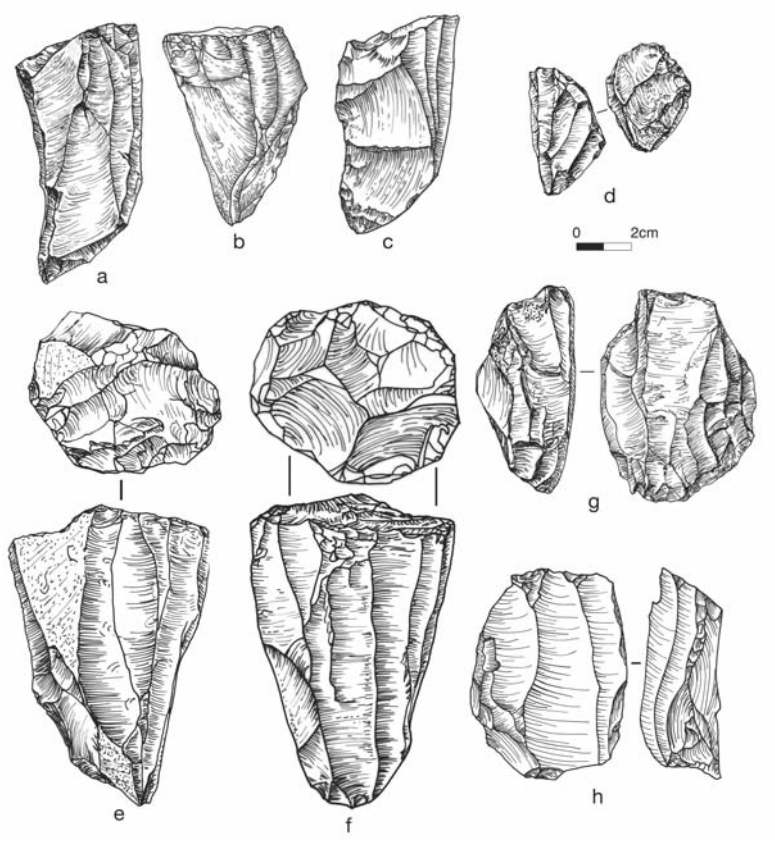

FIGURE 7.3.
Bladelet and blade cores: (a) Solutrean bladelet core; (b-d) pre-Clovis bladelet cores; (e) face and top view of Solutrean polyhedral blade core; (f) face and top view of Clovis polyhedral blade core; (g) face and side view of Solutrean wedge-shaped blade core; (h) face and side view of Clovis wedge-shaped blade core.

ducing surface. The same basic strategy was used in the production of microblade cores in Beringia, but most of the microblades themselves were produced by pressure.

The Solutrean is the only assemblage in Upper Paleolithic southwestern Europe with precores prepared with single bifacial ridges and flat, often unmodified backs. The resulting cores regardless of form do not have bifacial back ridges.

Two large blade production strategies were shared by Solutrean, pre-Clovis, and Clovis knappers, resulting in different core types: wedge-shaped and conical. Conical cores have a single platform and unidirectional blade removals (figure 7.3d–f). Wedge-shaped cores have a single primary platform and mostly unidirectional blade removals (figure 7.3g–h). Occasionally a blade would be struck from their distal end, but this seems to have been done to correct flaking errors rather than systematically to produce the desired blades. Intentional bi-directional flaking from opposed platforms occurs in some Solutrean as-

semblages. This technique was also common in earlier and later technologies in Eurasia; however, Solutrean cores are the only ones with flat backs.

The wedge-shaped cores in Clovis sites were produced with the same techniques as the Solutrean cores and are unlike those made by any of the cultures in Beringia or any other European Upper Paleolithic culture. The technology of the conical blade core forms in Clovis has been reconstructed in detail, and these forms resemble Solutrean examples and some blade cores in sites less than 13,000 years old in the Russian Far East and Alaska.[4]

Our knapping experience with unidirectional blade technologies indicates that many of the blades they produce are slightly to moderately curved, well suited to the production of the scrapers and other unifacial blade tools found in Solutrean, pre-Clovis, and Clovis assemblages.

BLADES, BLADELETS, AND BACKED BLADES

A comparison of Solutrean, pre-Clovis, Clovis, and non-Clovis blade dimensions indicates that most of the Solutrean blades in our sample fall into the same metric range as Clovis, as do the specimens from the pre-Clovis sites in the Chesapeake Bay area. The large quartzite blades from Cactus Hill and from northern Spain group together but are still within the range of the Solutrean-Clovis continuum. Post-Clovis blades from Texas and New Mexico fall outside the range of the earlier blades.[5] All of these are significantly larger than the early blades (microblades) in Beringia. Some blades in the Russian Far East, the earliest of which are of Clovis age (figure 3.3g), are a possible exception.

Although North American researchers have not generally reported tools made from blades with pressure-flaked retouched edges (called backed blades), these do appear in Clovis assemblages. Backed blades and used bladelets have been found at the Gault Site in Texas, the Bostrum Site in Missouri, and the Paleo-Crossing Site in Ohio.[6] A backed blade with flat pressure flake scars on the ventral face and a blade with an abruptly beveled truncated distal edge were found at Jefferson Island (figure 4.10f–g).

HEAT TREATMENT

Heat treatment of stone to enhance its flakability is a sophisticated process that demands careful control and, if improperly applied, can result in significant wastage of stone. This procedure is especially useful where raw materials are intractable and flaking techniques include substantial biface percussion thinning or pressure flaking (including using pressure to produce microblades). Heat treating first appeared during Solutrean times in Europe, and although it is not often recognized, it occurs in pre-Clovis and Clovis assemblages. Two heat-treated side scrapers and an end scraper were found at the Lower Meekins Neck Site (18DO70), a Clovis site in Dorchester Country, Maryland.[7] Heat treating is also reported at the Anzick Site in Montana.[8] This may be another trait that links Solutrean

and Clovis and excludes other early technologies, such as those found in Beringia, but its presence has not been sufficiently evaluated in many of the other assemblages (including pre-Clovis) to be certain.

EXOTIC STONE

Another cultural trait that seems to be distinctive of the Solutrean and Clovis cultures is their inordinate use of exotic types of stone for the manufacture of some of the more specialized flaked artifacts. Many archaeological assemblages of different periods include artifacts made of stone from non-local and at times far distant sources, and this can be a reflection of group mobility (figure 2.4). In Clovis and Solutrean assemblages the intentional selection of certain rare and exotic stone types seems to have gone well beyond expediency and mobility. Although it is likely that Clovis people, especially in western North America, were highly mobile and would have encountered rare and exotic stones during their travels and explorations, their focus on certain types, especially quartz crystal and red fine-grained stones, is noteworthy. It is also clear from the Clovis caches that high-quality exotic materials were preferred for many of the oversize, possibly ritual, pieces. Exploitation of these rare sources also demonstrates Clovis knappers' intimate knowledge of the geography of vast territories. The special selection of exotic materials by Solutrean knappers is even more remarkable: whereas Clovis knappers had untapped or at most lightly used resources to choose from, Solutrean people lived in areas where knappers had been exploiting stone sources for tens of thousands and even hundreds of thousands of years. Yet there is a clear selection during the Solutrean for rare and exotic materials, especially quartz crystal, chalcedony, and jasper.

Did these intentional selections of exotic stones, especially quartz crystal, represent an expression of aesthetics? Were the artifacts made from special raw materials perceived to hold symbolic value or power? Although this type of cultural behavior might arise independently, its presence in Solutrean and Clovis assemblages and absence from the other early assemblages in our study is striking.

To date, a purposeful selection of exotic raw materials has not been identified in the pre-Clovis assemblages in eastern North America. This could be used to argue against the Solutrean–pre-Clovis–Clovis continuum, but the samples are as yet very small. The one possible example of exotic material selection could be at Meadowcroft, where Flint Ridge stone was present, although this could be the result of mobility rather than special selection. The pre-Clovis flintknappers at Miles Point used locally available stones, perhaps indicating that they had not yet explored enough of the interior to find exotic sources. By contrast, at the Jefferson Island occupation, just a few miles from and thought to be several thousand years later than Miles Point, all of the artifacts are made of raw materials from more distant sources. This indicates that the Jefferson Island people explored the interior and found better stone sources than what was available in their immediate area.

BONE, ANTLER, AND IVORY TECHNOLOGIES

Bone, ivory, and antler artifacts are scarce in late Pleistocene sites, especially those exposed to weathering or in acidic environments. This includes most of Beringia and eastern America except Florida, and only to a lesser extent western America and southwestern Europe. Nevertheless, some of these artifacts have been recovered.

The most abundant bone tool assemblages are from the caves and rock shelters in southwestern France and northern Spain. Although some artifact types occur in diverse archaeological cultures, others seem to be restricted to specific periods. Bone, antler, and ivory points are the most common, and the most abundant type are known as sagaies. These are rods that taper to a sharp point at one end and have a single bevel at the other. Sagaies vary in cross section, size, and proportion throughout the Gravettian, the Solutrean, and into the Magdalenian in southwestern Europe but are most abundant during the Solutrean. A split-base style distinctive of the Aurignacian drops out during the Gravettian (figure 5.1e–f). The simple sagaie form is retained in the Magdalenian but is supplemented with a wide range of styles, many of which have multiple carved barbs.

Virtually identical sagaies have been recovered from nearly a dozen fluted point sites, most in western North America, where soils are neutral to slightly basic, and from areas in northern Florida where waterlogging has favored their preservation. Although the association between the Florida pieces and fluted point assemblages is tenuous, the fact that most of these sagaies were made from fresh mammoth ivory places them in the fluted point era (or earlier). Not only are a large sagaie from a Solutrean level in Laugerie Haute in southwestern France and another from northern Florida virtually identical in form and size but both have zigzag decoration just above the bevel (figure 7.4c–d). If they had been found near each other we would be debating not whether they were from the same culture but whether the same person made them!

Other kinds of bone, antler, and ivory tools found in both Solutrean and fluted point sites include sagaie-like implements with rounded tips that probably preclude them from being projectile points. They could, however, have been foreshafts that were part of composite, harpoon-like weapons. The rounded, tapered tip could have been inserted into a flanged, hollowed-out harpoon-like socket, into whose other end a stone point would have been set, similar to examples from the Arctic (figure 7.5). There are no hollowed-out sleeves that clearly date to Clovis times, but an example dated to circa 11,000 years old was found associated with extinct faunal remains in a peat bog in Indiana.[9] We cannot be sure this specimen is a Clovis artifact, but we think it is just a matter of time before one is found in a clear pre-Clovis or Clovis context. Although not a true toggle harpoon, this weapon would have been effective in hunting sea mammals, especially during glacial times, when seawater was more buoyant, due to its relatively high salt content, keeping animals from sinking rapidly. The true toggling harpoon does not show up in Europe until Magdalenian times, when the inflow of massive amounts of freshwater from melting sea ice and glaciers diluted the seawater's salinity.

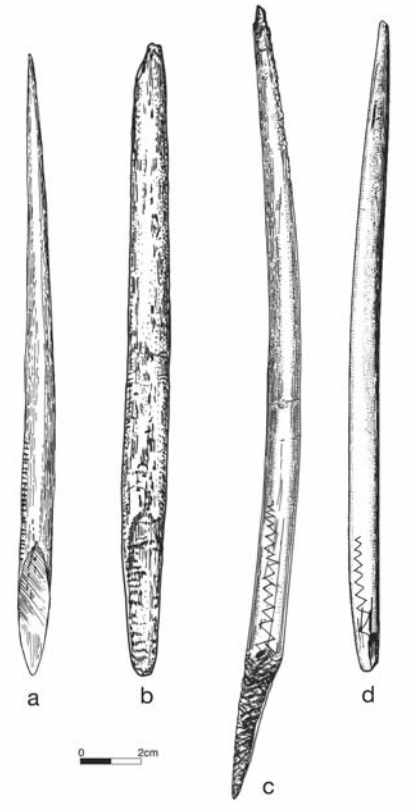

FIGURE 7.4.
Projectile points made of bone or ivory (sagaie): (a) Solutrean; (b) Clovis; (c) Clovis with zigzag design; (d) Solutrean with zigzag design.

Several robust bipointed ivory rods were found in Culture Zone IV at the Broken Mammoth Site in Alaska (figure 3.7g–h). This zone dates to between 13,000 and 13,500 years old, and the ivory is dated to nearly 19,000 years old, suggesting that it was scavenged from an older, frozen mammoth. Similar artifacts have been found in Solutrean deposits, but these rods are simple forms, and their superficial resemblances do not necessarily indicate a common origin.

The famous mammoth bone shaft wrench from the Murray Springs Site in Arizona (figure 2.13m) and the perforated antlers found in Upper Paleolithic sites in France may have served a similar function. The wrench was used to straighten wooden shafts, such as spears, darts, and arrows. Frequently shafts were slightly bent, causing the weapon to wobble in flight. To straighten a shaft, a hunter would have placed it into the perforation of the wrench, twisted, and levered against the wrench. Even today, people who hunt with primitive wooden weapons frequently use a shaft wrench on a daily basis. When we showed a cast of the Murray Springs shaft wrench to French colleagues, they remarked that it was virtually identical to one found at a Solutrean site. This relatively simple form is not specifically Solutrean and has been found associated with other Eurasian assemblages. It is not, however, a type of tool identified in Paleolithic Beringia.

FIGURE 7.5.
Speculative reconstruction of a Clovis harpoonlike bone weapon system: (top) bone foreshaft from Anzick Site, Montana, and foreshaft socket from an Indiana peat bog; (middle) assembled foreshaft, socket, and Clovis point from Anzick; (bottom) side view of foreshaft inserted into foreshaft socket.

Finally, delicate eyed bone needles exist in both the French Upper Solutrean (figure 7.6b) and the Folsom collections (figure 7.6a and c). Clovis sites with intensive long-term occupations, where large-scale clothing and sewing activities would have been conducted, are situated in the east, where preservation is poor. Small bone items such as needles might be expected there but are absent, possibly because of acidic soils. One exception is

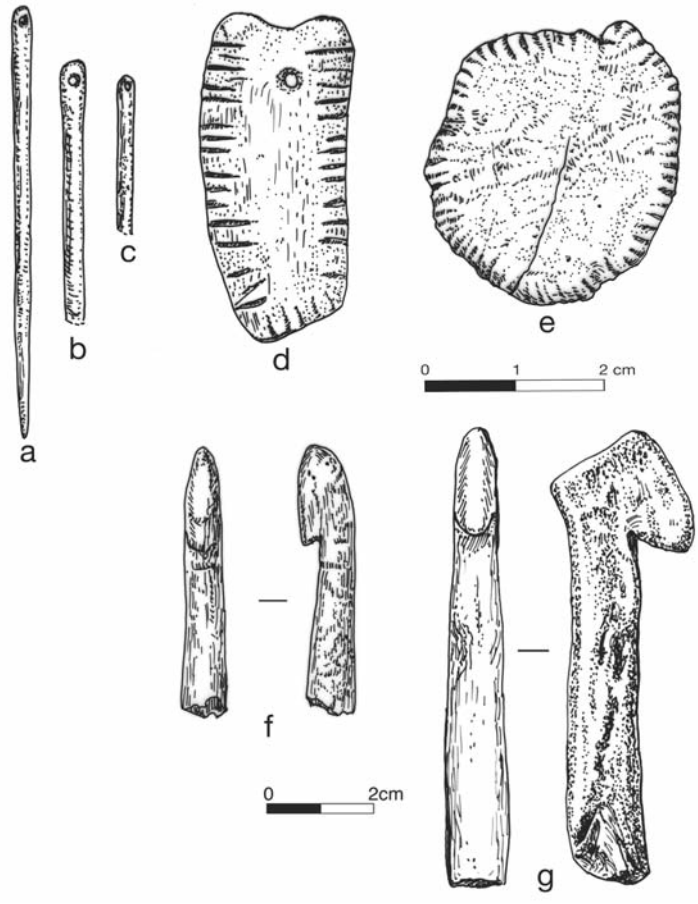

FIGURE 7.6.
Comparison of bone artifacts: (a) bone needle from Idaho; (b) Solutrean eyed needle; (c) Folsom bone needle from Colorado; (d) Solutrean notched pendant; (e) Folsom notched disk; (f) front and side view of bone Solutrean atlatl hook; (g) front and side view of bone atlatl hook from Florida.

Sloth Hole, a submerged wet site in northern Florida, where at least two purported unperforated ivory needle fragments have been recovered.[10]

Western Clovis sites in areas with neutral to basic soils that provide relatively good conditions for preservation are kill sites and caches where only specialized activities were conducted, most not requiring the use of delicate tools like the eyed needle. One might expect to encounter needles at the campsites associated with kills, but so far that has not happened, presumably because those sites contain few artifacts and were used for very short durations. It is not until Folsom times, when we get large, longer-term habitation sites with good organic preservation, that eyed needles and other delicate bone artifacts become relatively common.

With the possible exception of some of the submerged assemblages in Florida, bone

tools have not been found in pre-Clovis contexts.[11] Once again, this may be partly due to sample size and poor preservation, and the inundated early sites might produce this evidence, if it exists. However, several ivory atlatl hooks, thought to be associated with Clovis or pre-Clovis artifacts, have been found at a site in the Santa Fe River (figure 7.6g). Among these are several made in the same style as Solutrean atlatl hooks (figure 7.6f). There is no evidence of the use of atlatls by Siberian Paleolithic people.

CULTURAL BEHAVIORS

While our discussion to this point has centered on comparison of technological futures of stone and bone artifacts, other cultural behaviors found among Solutrean and Early Paleo-American cultures appear to link them into a historical relationship.

ARTISTIC EXPRESSION

The Solutrean in France and northern Spain is well known as having an extremely rich artistic tradition, especially in cave paintings, such as those at Altamira. With the exception of a couple of possible Clovis pictographs of mammoths in the west, there are no equivalents in any of the archaeological cultures in this study. Art engravings on artifacts small enough to be transported as well as objects used for personal adornment exist in Solutrean and other western European Upper Paleolithic contexts.

A common feature in late Solutrean deposits is multi-notched bones, usually bone points notched on both sides. We also find small bone disks incised or notched around their perimeters (figure 7.6d). These disks could have had any number of uses, for instance as gaming pieces, counting or numeric devices, or simply art or objects of adornment. Although notched-bone objects have not been found in Clovis sites, similar bone disks are part of post-Clovis Folsom artifact assemblages (figure 7.6e), perhaps indicating the continuation of this Paleolithic tradition.

Engraved bones and stones also occur in Solutrean and Clovis assemblages, some with geometric designs, while others depict naturalistic images of animals (figure 7.7g). A mastodon figure etched on a probosidian bone fragment has recently been reported from Viro Beach, Florida (figure 7.7h).[12] During the past several years incised flat limestone pebbles similar in size, shape, and to a lesser extent design to those in Solutrean collections have been found in Clovis contexts at the Gault Site in central Texas (figure 2.14). These Gault specimens are decorated with geometric designs, one of which depicts an over-and-under weaving pattern and another that has been interpreted as a running fox. The Gault Site also included a double-sided incised clast with a series of dart shafts with fletching (figure 7.7a), similar to stones from Polesini, Italy (figure 7.7b–e), and Parpallo Cave, Spain (figure 7.7f), where, as at Gault, a large number of incised stones have been found.[13] A single incised slate fragment was encountered in the post-Clovis level of the Ushki Site in western Beringia, but this type of artifact has not been seen in eastern Beringia.

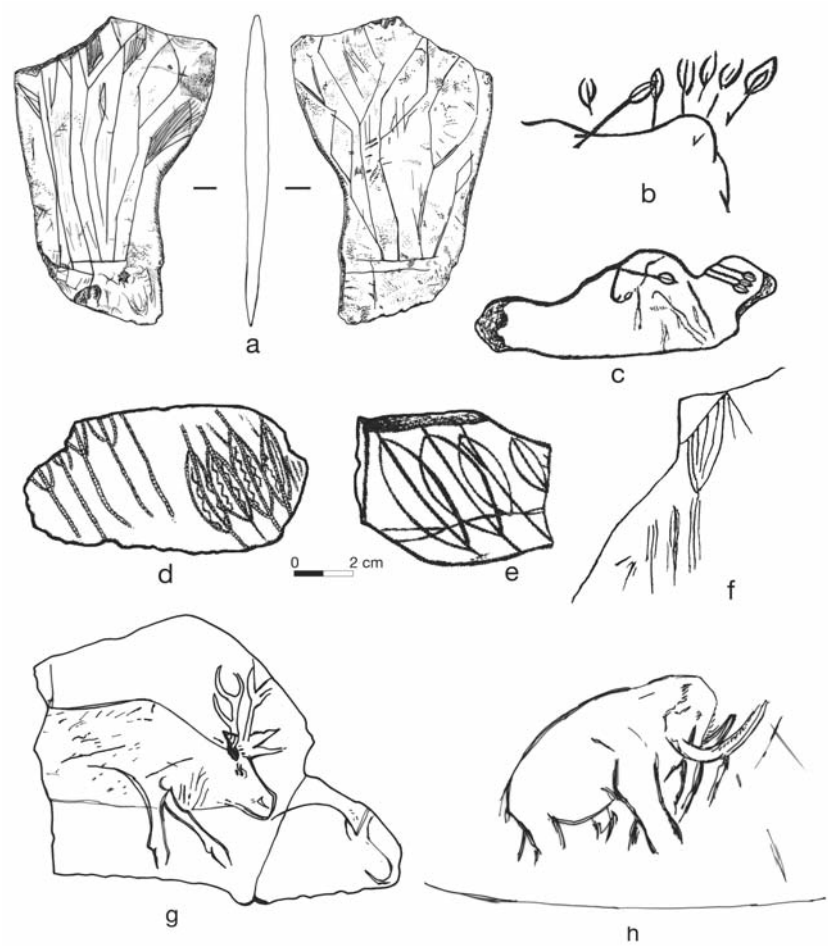

FIGURE 7.7.
Incised stones thought to show fletched spears: (a) obverse, side, and reverse views of Clovis incised stone from Gault, Texas; (b–e) Solutrean-age incised stones from Polesini, Italy; (f) incised stone from Solutrean level, Parpallo Cave, Spain; (g) Solutrean zoomorphic deer design; (h) engraved mastodon on bone from Viro Beach area, Florida.

The absence of cave paintings associated with fluted points or Beringian sites may be attributed to the scarcity of caves and shelters where they could have survived the ages or even been executed. This is especially true on the eastern seaboard and vast plain of the continental shelf, where caves would have been rare to nonexistent. In such an area, pebble engraving may have been a durable outlet for artistic ambitions, and the impetus for cave painting lost.

It may not have been just a matter of availability, however. The tradition of cave painting in Europe did not last past the end of the Pleistocene, even in areas where cave art had flourished in earlier times. Nobody can deny the existence of a thriving cave paint-

ing tradition during the Upper Paleolithic, culminating in the Magdalenian. But the operative word here is *culminating*. Why was this rich heritage abandoned by people who we believe were direct descendants in the same place? It had gone, even in the core areas of southwestern Europe, by the time the fluted point tradition developed in North America. If it died out in areas where it had flourished for thousands of years, why should we expect it to have been transmitted over long, caveless distances?

Personal adornment is associated with modern human beings and makes its appearance in western Europe during the early Upper Paleolithic, around 35,000 years ago.[14] Various forms of beads and pendants are well represented in Solutrean sites. Most recognizable ornaments are drilled and perforated, but many other less obvious items may have served the same purpose. Similar objects have been recovered from sites in Beringia, but none more than 9,000 years old have been found in eastern Beringia.[15] Neither beads nor pendants were found in the earliest levels at any of the pre-Clovis sites, but once again this may have more to do with preservation and sample size. It is clear that Clovis people made beads for personal adornment, although they are rare in the record. A bone bead preform was recovered at Blackwater Draw, New Mexico, and a stone bead was found near the Clovis point at Shawnee Minisink, Pennsylvania. At the larger western Folsom campsites, beads are part of the cultural inventory, but a drilled bone bead from the Shifting Sands Site in west Texas was so small it was recovered only because it was stuck to a Folsom artifact by a calcium carbonate crust and came loose after the stone tool was placed in a specimen bag.[16]

EXTRAORDINARY BIFACE CACHES

Extra-large, extremely well made bifaces have been found buried in groups, sometimes with other kinds of artifacts and frequently with concentrations of red ocher. This caching of extraordinary artifacts has been found in only two more-than-13,000-year-old archaeological cultures: Solutrean (figure 7.8a) and Clovis (figure 7.8b). For both cultures, researchers have suggested that some of the artifacts were made for non-utilitarian purposes and that their very manufacture held special symbolic and ritual meaning.[17]

In all of western Beringia there is only a single reported biface cache, so called even though the cluster of eight bifaces was found scattered around a small area in a final stage Dyuktai occupation level at the Tumular Site in the Aldan River Valley, Siberia.[18] The bifaces in this cache are likely preforms for microblade cores and in any event not comparable to the caches of large bifaces found in Solutrean and Clovis contexts. They are not of special manufacture and probably represent provisioning behavior: leaving a collection of microblade precores for future retrieval. Two similar provisioning caches of precores have been reported from eastern Beringia, one at Onion Portage on the Kobuk River and other near Point Barrow.[19] A radiocarbon date from the Onion Portage Cache suggests that both caches are likely post-Clovis in age.

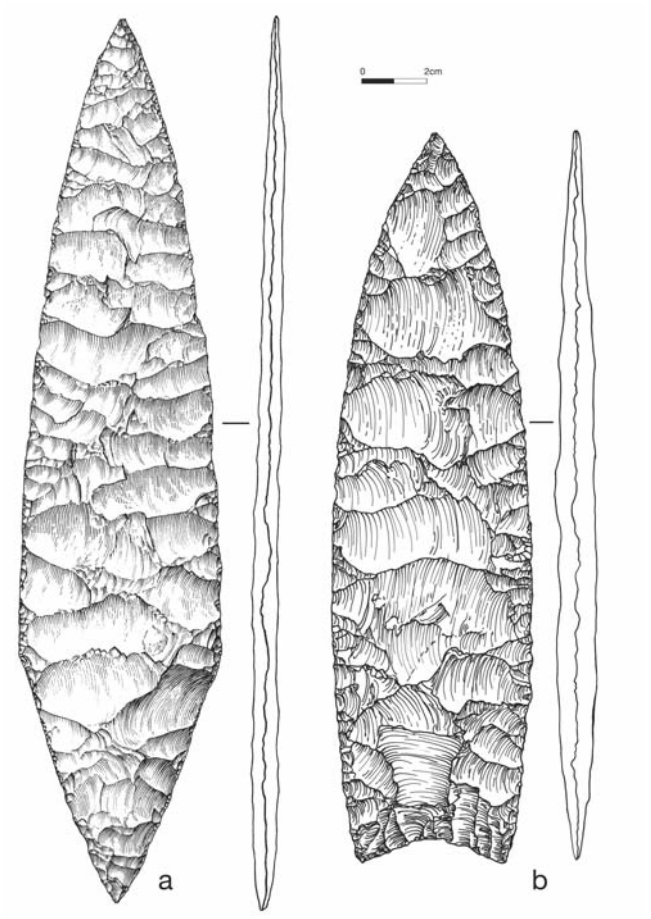

FIGURE 7.8.
Oversize bifaces from caches: (a) Solutrean; (b) Clovis. Outlines show the extremely thin sections.

SHELTERS

Remnants of shelters or structures have been described in western Beringia, specifically at Ushki Level VI. These take the form of shallow circular depressions, often with a fire pit near the center. Some artifact clusters in eastern Beringian sites have been interpreted as indicating outlines of former shelters.

Evidence of constructed shelters is absent from the Solutrean, but this is probably because most of the excavations have been in caves and rock shelters, where they were not necessary. Purposefully laid cobble floors found at early Magdalenian sites in southwestern France are, however, possible remnants of dwellings (figure 7.9a).[20] These features consist of cobble pavements laid out in square or rectangular patterns measuring a few meters on each side. Some also exhibit small extensions in the center of one or more sides. Artifacts tend to be present in concentrations in and around the features. In addition, all but two are aligned with the cardinal directions.

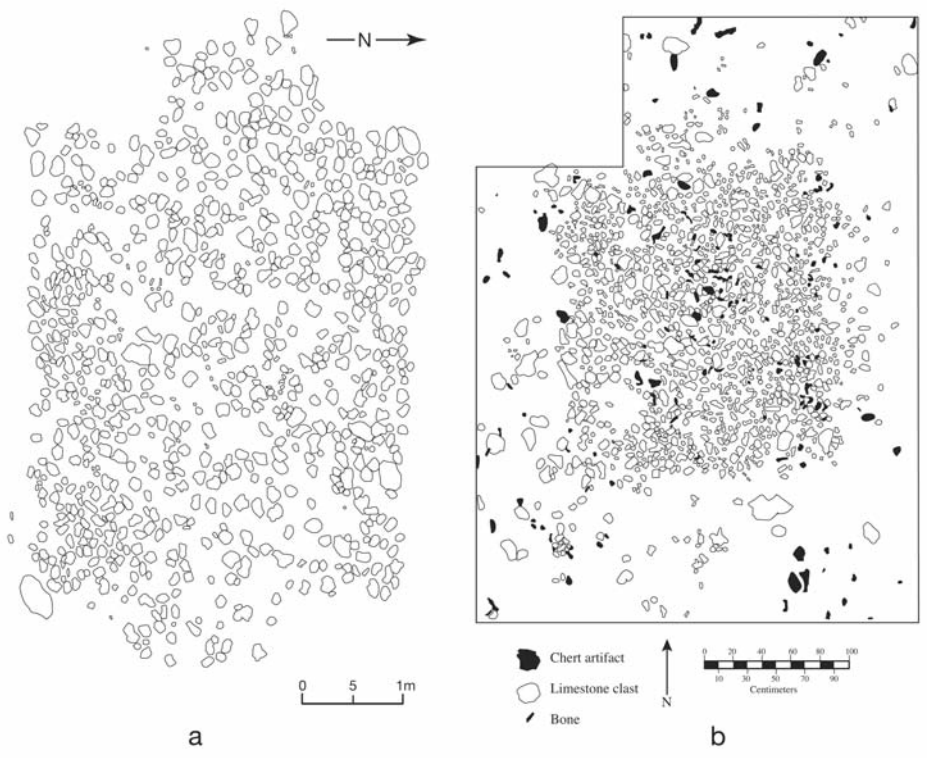

FIGURE 7.9.
Comparison of structure pebble floors: (a) Lower Magdalenian, France; (b) Clovis/pre-Clovis, Gault Site, Texas.

The rectangular pebble floor at the Gault Site (figure 7.9b) is highly reminiscent of these European features. It measures about 2 by 2 meters, is oriented in the cardinal directions, and has a small portico square centered at the north end. Use-wear studies of blade tools found around this floor indicate that reed matting was manufactured here, perhaps for flooring or external coverings.[21] To our knowledge this type of floor does not appear in other Paleo-Indian campsites and may represent a long-lasting European Paleolithic construction technique.

FIRE HEARTHS

A distinguishing feature of Paleo-Indian sites is that their fire hearths were not stone lined. By contrast, many Solutrean fire hearths are lined with cobbles, although examples of unlined fire hearths were found in the lower Solutrean levels 4, 5, and 6 at La Riera Cave.[22] It is probably not coincidental that these are the levels that produced all of the indented base projectile points found in situ, as well as exotic cherts, seal bones, and major accumulations of limpet shells and fish remains. This suggests that these levels represent tem-

porary hunting camps used by people who were based on the coast and likely exploited the resources of the Atlantic Ocean. Their artifacts and camp debris are most comparable to the American pre-Clovis and Clovis camp situations. If Clovis descended from this branch of Solutrean peoples, perhaps unlined Paleo-Indian hearths were a continuation of the latter's practice.

MORTUARY PRACTICES

While it is difficult to use lack of evidence as evidence of a relationship, we must point out that no Solutrean or Clovis burials have been found. Unlike with other Paleolithic European, Siberian, and later North American cultures, which all have evidence of mortuary customs, we have no idea how the earliest Paleo-Americans or Solutrean people buried their dead. Both groups apparently used a form of burial that did not preserve the human remains. Their customs may have been similar to the historic scaffold type of burial, wherein the body was left in an open environment to facilitate transformation to another dimension. Some investigators think the remains of two individuals recovered at Anzick Site in Montana are associated with the Clovis artifacts there.[23] However, radiocarbon dating of the human bones indicates that they were placed near the cache 400 or more years later.

The lack of human remains from both cultures renders it impossible to assess their paleo-genetic relationships.

CONTRARY EVIDENCE IN ARTIFACT TYPES

We would be remiss if we did not discuss typical Solutrean artifacts that are not present in the New World. Given the changing environmental conditions and adaptations to these shifts during the time span represented by the Solutrean–pre-Clovis–Clovis continuum, it is no surprise that some tool types would fall out of favor and new types be introduced. The resulting differences among the assemblages can be as interesting and explanatory as the similarities.

PROJECTILE POINTS

Some Solutrean projectile point styles are absent from pre-Clovis and Clovis assemblages, including several varieties of shouldered points primarily defined by their method of manufacture, willow leaf points, and stemmed and corner-notched points.

In France, blade-based shouldered points occur in Solutrean deposits after 19,000 years ago. They exhibit unifacial pressure flaking, although many examples are partly flaked on both faces and some are completely bifacial. In northern Spain, Solutrean shouldered points were mainly made by limited, abrupt, probably anvil-supported percussion on blades. The conclusions of several studies, including replication and use experiments, are that they were used to tip projectiles, but whether for darts or arrows is still being debated.

If pre-Clovis and Clovis tool forms descended from the Solutrean, why are shouldered points absent from the former? There are several possible answers. First, it is common for some artifact types to drop out of a cultural inventory, especially but not necessarily if functional requirements change. Second, not all Solutrean assemblages include shouldered points. If the particular Solutrean people who eventually found their way to North America came from a group or groups that didn't use shouldered points—perhaps, based on radiocarbon dates from the Chesapeake Bay sites, because they left Europe before the advent of this technology—one wouldn't expect these artifacts in North American assemblages.

In some Solutrean sites several point types occur in the same occupation. Such a mix may have many explanations, particularly in an area geographically restricted for thousands of years like the Vasco-Cantabrian region. Different bands may have used socially identifiable, unique symbols such as point types and other markings, so middens with mixed types may be the result of such circumstances as cooperative hunting ventures or occupation by different contemporary groups operating in overlapping territories.[24]

Some French Solutrean sites have yielded a form of artifact called a willow leaf point. These resemble the finer pressure-flaked Solutrean shouldered points, but they lack the shoulder. To our knowledge these points have not been subjected to use-wear studies, but along with many of the thin laurel leaf points, they may have been used as knives. Again, this form developed late in the French Solutrean and may not have been in the inventory of the people who adopted a maritime economy and eventually traveled to North America.

Stemmed and corner-notched projectile points have been found in Mediterranean and Portuguese Solutrean sites. These weapon tips, thought by some researchers to be arrowheads, are not present in northern Spain or southwestern France, so there is no reason to expect Vasco-Cantabrian descendants in North America to have used them. Conversely, indented base points do not appear south of the Cantabrian Range.

In our hypothesis, technological innovations also occurred after people arrived in the New World. Even though many of the Spanish indented base points are basally thinned and a few might be classified as multiple fluted, we do not subscribe to the idea that there is an Old World antecedent of fluting technology. Fluting is not a common means of basally thinning bifaces in other times and places and is probably not a major technological advantage. It is unclear how and why it developed, and since it does occur in some pre-Clovis bifaces, we suspect that this particular technique was an American invention.

BACKED BLADELETS

Small blades and bladelets were part of most Upper Paleolithic assemblages in western Europe. Some consider the paucity of backed bladelets in Clovis assemblages significant, but like shouldered points they are not universal in the Solutrean either. For example, at La Riera there are no backed bladelets in nearly a third of the lower occupation levels; moreover, 81 percent of the artifacts at La Riera came from occupation levels that did not contain any stone projectile points, and roughly 75 percent of them came from the two

upper occupation levels.[25] These data suggest that by later Solutrean times slotted bone or antler projectile points were the primary weapon tip for hunting in this upland setting.

Backed bladelets may have been part of a variety of items other than projectile points but were mainly used like razor blades and may have been inserted into slotted bone knives. Sagaies slotted for inset blades appear during the final stages of the Solutrean occupations of northern Spain, likely as a result of influence from other European Paleolithic technologies. Since slotted sagaies have not been found in any Clovis context, it appears that Solutrean people adopted this technology after the ancestors of pre-Clovis found North America, or in subgroups not directly related to the New World descendants. On the other hand, slotted sagaies armed with microblade insets became the dominant weapon technology in western Beringia long before any putative Clovis ancestors might have crossed the Bering Sea.

BURINS AND ADZES

A burin is a tool created by striking a flake or flakes from the edge of an artifact to produce a sharp 90 degree edge for working hard substances such as ivory, antler, and bone. The edge fragment, usually triangular or square in cross section, that was removed to make the burin is called a spall. Although a few burins have been found in Clovis artifact assemblages, they are rare. A burin and a spall were found at Miles Point, and a burinated blade was recovered from Jefferson Island. A burin-like tool was also recovered at the Coats-Hines mastodon butchering site in Tennessee. By contrast, at La Riera Cave burins make up about 10 percent of the stone tools recovered from the Solutrean levels. They are also extremely common throughout the Siberian and Beringian Paleolithic cultures. Apparently, for some reason burins lost their importance and were dropped from Clovis technology, regardless of whether their Paleolithic origins were in Iberia or Siberia. However, burin-like tools that may have functioned in the same way have been recovered. These were produced not by edge removal but rather by radial breakage of thin, mostly biface flakes.[26]

Woodworking adzes occur in some Clovis and pre-Clovis sites but not in Solutrean or Beringian collections. We believe that this tool type has not been found in Solutrean assemblages because the sources of wood in the upland areas where Solutrean material culture has been defined were limited. Driftwood from North America that washed up along the coast would have been the only source of large timber for the Solutrean people. Consequently, evidence of adzes and other tools that may have been used to make boats or for other construction projects are now underwater.

CLOSING THE CHRONOLOGICAL GAP

The impression that the Solutrean and Clovis are separated by approximately 5,000 years is often cited as the fatal flaw of our hypothesis. Unless there exists a reasonable series

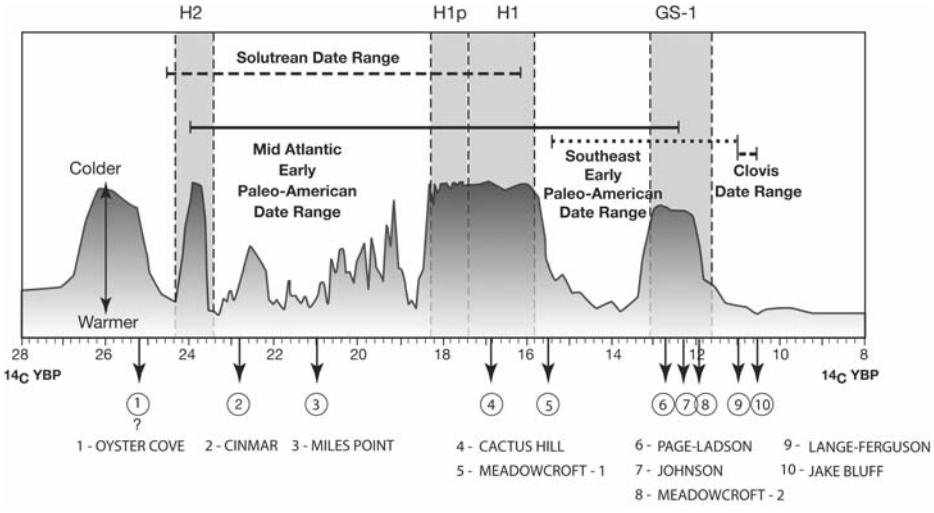

FIGURE 7.10.
Radiocarbon date ranges of the Solutrean, Mid-Atlantic Early Paleo-American, Southeast Early Paleo-American, and Clovis.

of dated archaeological cultures with intermediate bridging technologies to fill the gap, like those before us who saw the similarities of Solutrean and Clovis technologies, we would have to consider the shared traits as independent inventions rather than historic relatives, whether related to Beringia or the Solutrean. The oldest of these bridging technologies would need to have artifacts that are nearly identical to the parent Solutrean technology, and the youngest should begin to closely match Clovis technology.

This is where the pre-Clovis evidence from the eastern United States fits in (figure 7.10). The radiocarbon date of the Cinmar mammoth indicates that the Solutrean-style laurel leaf biface associated with it may date to at least 22,760 years old (see chapter 4). The Cinmar age is consistent with the date of greater than 21,000 radiocarbon years before the present for the occupation of Miles Point. The artifact assemblage from Miles Point includes biface projectile points, blades, scrapers, and burins that are technologically close to artifacts found in Solutrean levels 4, 5, and 6 at La Riera Cave that date to 20,970±620 RCYBP. The 16,940±50 RCYBP date for the pre-Clovis occupation at Cactus Hill also overlaps with the dates of later Solutrean occupations of the Vasco-Cantabrian area of Spain. However, the pre-Clovis artifact assemblage from Cactus Hill does not include the late Solutrean inset bladelet technology. At Page-Ladson, dated to circa 12,388 RCYBP, and related sites such as Jefferson Island, we see the continuation of blade and burin technology, but the projectile point technology now includes larger, unfluted "Clovis-like" projectile points. At the Johnson Site in Nashville, Tennessee, early attempts at systematic basal thinning are evident, but the Clovis technique of platform preparation for fluting has not been perfected, and there is a high rate of failure during final fluting

attempts (figure 4.11). The Johnson Site bifaces are associated with Solutrean-style artifacts including a plane face point (figure 7.1m) and Solutrean scrapers (figure 7.1a–c) and blades. This evidence suggests that Johnson was occupied by proto-Clovis people, provides a date for the development of techniques to flute Clovis points, and serves as a transition between early Mid-Atlantic Paleo-American and Clovis technologies.

The Cinmar date of 22,760 RCYBP pushes the presence of people in North America back to the time of the Solutrean culture. Clearly the chronological gap has been closed, and the high number of corresponding flaked stone and bone tool forms and technologies make a historical connection feasible.

COMPARATIVE SUMMARY

We have compared the chronology, tool types, and technology of the archaeological remains in late Pleistocene Beringia, continental North America, and southwestern Europe in an attempt to identify historical relationships. When we had large enough samples of artifacts, we compared tool assemblages and flaked stone technology and submitted them to cluster analysis. This allowed us to see what assemblages clustered, how they clustered, and what distinguishing attributes determined the clustering.

Our cluster analysis distinguished between different types of sites in fluted point and eastern Beringian assemblages. However, it also indicated to us how inconsistently archaeologists have recovered, analyzed, and reported sites and assemblages over the past century. This is a major obstacle to investigating the origins of people in the New World, but our initial efforts show that some reasonable conclusions can be drawn.

Comparisons of less quantifiable aspects of the archaeological record, including rarely recovered artifact types and various behaviors, have shown strong similarities between the fluted point and Solutrean traditions and a near lack of correspondence between fluted point and early Beringian traditions. The Nenana Complex shows the strongest similarities with Clovis, but Nenana is at best contemporaneous with Clovis and significantly younger than early Mid-Atlantic sites, raising the question of which may have been derived from which. Based on the available data, we would argue it is likely that certain aspects of Nenana and the Arctic Paleo-Indian assemblages were derived from people to the south, perhaps related to a northern branch of Solutrean descendants, rather than the other way around.[27]

There are sufficient similarities between all of the circa 12,000-to-14,000-year-old archaeological cultures of eastern Beringia to suggest that they originated from the Upper Paleolithic microblade traditions of Eurasia. At the same time, in our opinion, the technological, behavioral, and dating evidence overwhelmingly support the theory that the fluted point traditions in North America derived from a regional and chronological variant of the Solutrean cultures of southwestern Europe. The only alternative, as opined by the archaeologist Gary Haynes, is to assume that the complex technologies of the fluted point traditions sprang out of an entirely alien Asian technology without transitional

phases.[28] As flintknappers and lithic technologists, we seriously doubt that such a scenario ever happened; complex technologies require developmental antecedents even if introduced by foreigners.[29]

Although we have used general Solutrean artifacts, technologies, and behaviors in this analysis, we think it unlikely that all areas where Solutrean culture existed were directly involved in the colonization of eastern North America. It is more likely that only one relatively small area within the Solutrean sphere contributed to this process. The best fit we can find for the site of pre-Clovis ancestors, considering both the artifact assemblages and the known environment at the time of greatly lowered sea levels, is the area adjacent to the Bay of Biscay, where the Pyrenees meet the sea. Here the ancient beach line would have been clear of ice at times and would have extended almost straight along the Celtic continental shelf to several hundred kilometers west of glacier-covered Ireland. In other words, we hypothesize that the people who brought Solutrean traditions into the Americas were from the modern Aquitaine of France and Vasco-Cantabria of Spain—the Basque areas of southwestern Europe, and perhaps more specifically the adjacent submerged areas in the Bay of Biscay.

We frequently hear the argument that the absence of a well-documented Clovis predecessor in northeastern Asia just means we have not found it yet. To us the problem seems to be not the lack of a good candidate but where that candidate is located. Our guess is that no one would question the Solutrean origin of Clovis if Solutrean sites were found in northeastern Asia instead of southwestern Europe.

8

THE SOLUTREAN MARITIME ADAPTATION

> Always, then, in this flotsam and jetsam of the tide lines, we are reminded that a strange and different world lies offshore.
>
> RACHEL CARSON, *THE EDGE OF THE SEA*

The preceding chapters provide information that illustrates the strong correlations between Solutrean technologies of southwestern Europe and the earliest technologies found in eastern North America. There is a possibility that these could be the consequence of independent invention, but we have argued for a historic relationship. To consider this proposition further, we pose models of how and why a trans-Atlantic connection would have taken place.

Our hypothesis proposes that certain Solutrean groups expanded their terrestrial economic resource base to include maritime resources. Since the direct evidence of these maritime resources is mostly on the submerged continental shelf, the well-excavated Solutrean sites near the ice age coast in northern Spain provide the best clues for a maritime adaptation. Lawrence Straus and his associates have done some of the most recent and intensive excavations in this part of Spain. Their research on the Paleolithic occupation of La Riera Cave, in Asturias between Santander and Oviedo, has provided a springboard for the synthesis of more than a hundred years of Paleolithic archaeology in northern Spain. Moreover, they have published a wealth of data from which we can draw to build our models and hypotheses.[1] Hence, we can examine their Vasco-Cantabrian reports for evidence pointing to a shift from a terrestrial to a maritime economy, or to a mixed economy that exploited both biospheres. Because of this wealth of data , our model is based on the continental shelf of the Vasco-Cantrabrian region, but the Solutrean people who we hypothesize came to North America could have originated from any place along the Celtic or even the North Sea continental shelf.

Approximately fifty-two sites in the Vasco-Cantabrian provinces of northern Spain have

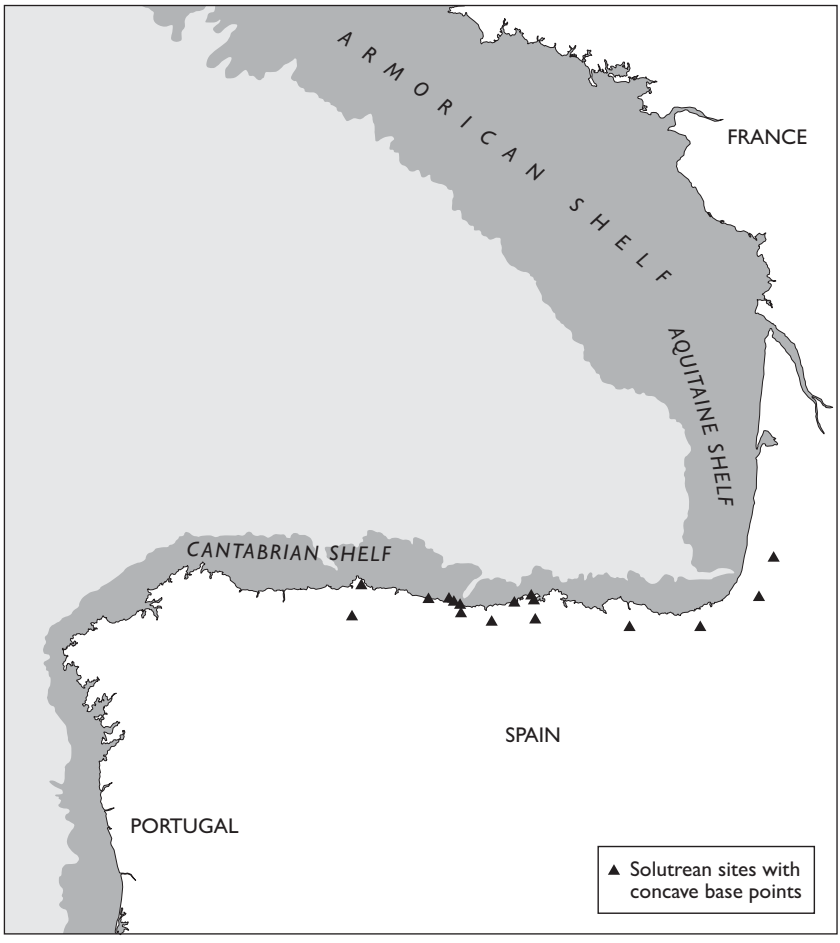

FIGURE 8.1.
Solutrean sites in northern Spain and adjacent southwest France. Triangles mark the Solutrean sites that have occupation levels where bifacial concave base projectile points were found.

been identified as occupied during the Solutrean period (figure 8.1). They are distributed along a narrow coastal strip that is roughly 350 kilometers long by 50 kilometers wide, stretching from the Nalón River in Austurias to the Bidasoa River in Basque country, bounded on the north by the Bay of Biscay and on the south by the then glaciated Picos de Europa. This area was roughly 20,500 square kilometers when it included the now submerged continental shelf. Solutrean sites appear to be evenly distributed throughout the region but concentrated along river valleys within 37 kilometers of the ice age coast.

The number of sites with known Solutrean occupations represents an approximately tenfold increase over the number of sites per millennium during the preceding Aurignacian and Gravettian periods. Geoffrey Clark and Lawrence Straus postulate that this increase reflects a growing human population as Iberia became a critical refuge for people

who abandoned northern Europe during the climatic crisis of the Last Glacial Maximum (LGM).[2] People fleeing territories rendered uninhabitable by the advancing glaciers and deteriorating climatic and hunting conditions migrated south and west, mostly ending up at coastal locations where the marine environments slightly moderated the inclement weather. Since the Vasco-Cantabrian coast is a relatively small and confined area, such an influx of population would have stressed its subsistence resources and reduced the size of the territories available to resident groups.

Clark and Straus also postulate a trend during the Solutrean of intensified food acquisition and suspect that specialized hunting methods, such as game drives, surrounds, and ambushes, were perfected to procure large numbers of animals during single episodes of hunting. Hunters developed new technologies, such as decoys, nets, movable fences, thrusting spears tipped with self-barbed points, spear throwers, and even bows and arrows, allowing them to be more efficient in capturing and killing game. Although there is no direct evidence for most of these methods, we agree with Clark and Straus that there was a broadening of the kinds of animal and plant resources that were regularly exploited for food.

If the increasing number of archaeological sites signals a similar increase in human population density, requiring an intensification of hunting, tremendous stress would have been placed on the local animal populations unless major new elements were incorporated into the subsistence economy. As Straus and Clark have pointed out, increasing niche breadth by adding new kinds of foods to the subsistence base is another result of territorial circumscription.

Any long-term increase in human population also eventually requires reorganization of its distribution to maximize the use of the available resources. A free-ranging settlement pattern with bands exploiting large territories, shifting from one valley to the next when resources were depleted, would have given way to smaller, more prescribed, exclusive territories. Local groups would then have become more familiar with resources that free-roaming bands had neglected in favor of those with a higher payoff, such as simply following a herd of horses into a neighboring valley.

As the population density increased, there would also have been a parallel development in social relationships that relieved resource stress and provided better mechanisms for dealing with normal periodic shortfalls and those caused by environmental catastrophes. A set of related social groups could have monitored game over larger areas and, when one area experienced a shortfall, obtained relief from another group. Other advantages would have been more predictable sources for marriage partners and trading partners, to name a few possibilities.

The archaeologist Louis Binford has said that "if intensification is indicated by a shift in exploitation from one type of biotic community to another, the shift will usually be to aquatic resources."[3] The evidence from La Riera demonstrates that the Solutrean people did broaden their niche by including aquatic resources. The question is, did they include marine sources beyond estuaries and beaches?

THE SOLUTREAN OCCUPATIONS OF LA RIERA CAVE

The stratigraphy in La Riera Cave provides an excellent picture of changing resource procurement strategies. The sixteen levels that contain artifacts attributed to Solutrean manufacture are thought to have been deposited between ca.18,000 and 20,500 radiocarbon years before the present. On the basis of the faunal remains, Straus and Clark suggest that the activities and types of occupations can be divided into three groups, from oldest to youngest: levels 2–3 were residential camps where bison and horse were the primary prey; levels 4–6 were temporary hunting camps; and levels 7–17 were residential camps from which red deer were intensively hunted.

A study of the faunal remains by Jesús Altuna provides more insight into the economic activities conducted in and around the cave, as well as the durations of occupation or at least the seasons when the cave was used.[4] His interpretations are unfortunately based on minimal samples, since the entire site has not been excavated, some levels were more intensively excavated than others, and the kinds and amounts of faunal remains removed by earlier excavations and by relic hunters are unknown.

From a total of 20,105 bones excavated from the sixteen Solutrean levels, Altuna calculated a minimum number of individual animals (MNI) in each level by comparing the bones present with the expected number of kinds of bones per animal. That is, each animal had a right- and a left-side upper hind leg bone (femur), and so on. If three upper left front leg bones (humeri) were found, we would know that parts of three animals had been brought into the cave. Conversely, the absence of certain bones, such as the lower rear leg, suggests that part of the animal was left at the kill site. These calculations indicate that at least 403 major food source mammals were consumed during the Solutrean occupations. Altuna also estimated in which month the younger animals died, from the eruption and wear patterns of their teeth. This tells us what time of year and for how long the cave might have been occupied.

Levels 2–3 were deposited during a cool, humid phase of the LGM. The faunal sample indicates that horses provided 56 percent of the available meat and bison 27 percent. Red deer and ibex provided 10 and 6 percent, respectively, supplemented by a single small chamois. The bones in the assemblage generally corresponded to the body parts that yield the largest amount of meat. This indicates that larger animals, such as the bison, were butchered in the field, where their less useful parts were left. By contrast, the presence of entire carcasses of smaller animals implies they were brought back to the cave for butchering.

Nearly a third of the horse and bison remains recovered at the site were encountered in the two earliest of the sixteen Solutrean levels. Although horses and bison are present in some of the later levels, only in level 7 do they approach the earlier frequency. The decline of these animals, which had the greatest payoff in terms of meat yield, may reflect overkill by the earliest Solutrean hunters or a shift in the habitat of these animals, or both.

Dental eruption and wear suggest to Altuna that the animals were killed from the end

of winter or beginning of spring into the summer. He also found that 33 percent of the horses were juveniles, 43 percent were of prime age, and only 22 percent were old individuals. These percentages are a nearly perfect match for the age structure of a living population, suggesting that the animals were killed as they were randomly encountered rather than as selected targets.

Considering the constricted dimensions of La Riera Cave, we suggest that more than fourteen people would have pushed its livability and thus that it was likely occupied by an extended family. We estimate that the occupants of levels 2–3 consumed a minimum of 6,424 pounds of meat in total (table 8.1).[5] This amounts to 2,443 person eating days, which could support a group of fourteen people for approximately six months.[6] That length of time matches the duration of the occupations of these levels as indicated by the seasonal distribution of the animals killed. If this was a continuous occupation, by the end of those six months accessible firewood would have been exhausted, the general area would have been soiled, and local game would have been scarce. The people probably moved to an area where horses and bison were still available, along with a fresh supply of fuel.

The next use of the cave (levels 4–6) took place during a cool and dry period, when hunters set up temporary camps there to process their game. During this time the remains of whole animals were brought for processing, the less economically important portions were discarded in the cave, and those parts bearing the majority of the meat were transported to another location for consumption.

Several more features of levels 4–6 set them apart from the other Solutrean occupations of the cave: all of the indented base point fragments found in situ came from these levels; all of the Solutrean artifacts made from stone imported from outside the valley are from these levels; the occupants of levels 4–5 brought up extraordinary amounts of mollusk from the coast; two-thirds of the anadromous fish remains come from these levels; the only seal bones are from these levels; both of the self-barbed spear points or pikes at the site came from level 4 (for an example, see figure 5.4c);[7] these levels' hunters selected prime-age animals; there is no evidence that the cave was used in the late spring or summer seasons; and the thinness of the occupation lenses (accumulated debris from human habitation) and presence of simple surface fire hearths rather than large rock-lined cooking features. All of these details imply that these levels were temporary camps used by hunters based in a residential camp elsewhere in the region.

Since the faunal data support the idea that these levels were not primary habitation locations and because these levels show a marked increase in food remains obtained from estuarine and riverine environments, we propose that the hunters who occupied the cave during this period came from base camps located near the coast, some 10 kilometers downstream. The faunal analyst Jesús Ortea suggests that women and children traveled to the coast to gather shellfish during their daily foraging rounds while the men were off hunting ibex.[8] That may well have been the case, but unless there was an estuary extending up a river, such a foraging expedition would have amounted to a linear round trip of at least 20 kilometers, which is 4 more than the average daily round-trip distances calcu-

TABLE 8.1 Faunal Remains from the Solutrean Levels of La Riera Cave

Level	Horse (average weight 396 lbs.)	Ibex (average weight 110 lbs.)	Bovid (average weight 880 lbs.)	Red Deer (average weight 220 lbs.)	Total Pounds Available	Person Eating Days at 2.63 lbs. Per Day	Number of Eating Days for a Maximum Disbursed Group (14 people)	Number of Months of Occupation
2–3	n=9 3564 lbs.	n=4 440 lbs.	n=2 1760 lbs.	n=3 660 lbs.	6424 lbs.	2443 days	174 days	9–3 or 3–9
4	n=2 792 lbs.	n=6 660 lbs.	n=2 1760 lbs.	n=3 660 lbs.	3872 lbs.	1472 days	105 days	nd
5	n=4 1584 lbs.	n=12 1320 lbs.	n=0	n=6 1320 lbs.	4224 lbs.	1606 days	115 days	nd
6	n=1 396 lbs.	n=4 440 lbs.	n=0	n=3 660 lbs.	1496 lbs.	569 days	41 days	nd
7	n=6 2376 lbs.	n=14 1540 lbs.	n=1 880 lbs.	n=34 7480 lbs.	12,276 lbs.	4668 days	333 days	1–12
8	n=1 396 lbs.	n=6 660 lbs.	n=1 880 lbs.	n=19 4180 lbs.	6116 lbs.	2325 days	166 days	1–5 or 5–1
9	n=1 396 lbs.	n=7 770 lbs.	n=0	n=25 5500 lbs.	6666 lbs.	2535 days	181 days	9–3 or 3–1
10	n=0	n=5 550 lbs.	n=0	n=12 2640 lbs.	3190 lbs.	1213 days	87 days	5 and 11–12
11	n=0	n=2 220 lbs.	n=0	n=13 2860 lbs.	3080 lbs.	1171 days	84 days	5–7
12	n=0	n=5 550 lbs.	n=0	n=9 1980 lbs.	2530 lbs.	962 days	69 days	nd
13	n=0	n=5 550 lbs.	n=0	n=11 2420 lbs.	2970 lbs.	1129 days	81 days	*
14	n=2 792 lbs.	n=8 880 lbs.	n=2 1760 lbs.	n=20 4400 lbs.	7832 lbs.	2978 days	213 days	*
15	n=2 792 lbs.	n=7 770 lbs.	n=2 1760 lbs.	n=15 3300 lbs.	6622 lbs.	2518 days	180 days	*
16	n=4 1584 lbs.	n=11 1210 lbs.	n=1 880 lbs.	n=27 5940 lbs.	9614 lbs.	3656 days	261 days	4–12 or 5–12
17	n=1 396 lbs.	n=8 880 lbs.	n=1 880 lbs.	n=16 3520 lbs.	5676 lbs.	2158 days	154 days	5–9

lated by Louis Binford for present-day women foragers.[9] Why would women travel so far for food when fresh ibex meat was probably entering the camp? Why would they bother to bring home a heavy load of mollusk in the first place, which require more energy to obtain and transport than would be gained by their consumption?

If, on the other hand, these people were operating out of a base camp 10 kilometers away from La Riera, near an estuary or on the beach, the distance to the cave falls within the range calculated by Binford for daily foraging trips by male hunters. At an average speed of 2.5 kilometers per hour, a trip to the cave and back would have taken roughly 4 hours each way, allowing little time for hunting, stalking, killing, field dressing any animals killed that day, and returning home. Hence, the cave might have been used for overnight stays or more likely for several days depending on hunting success and weather conditions. Unless the trip included fishing or other animal-killing activities, it would have been necessary to bring trail food—for instance, mollusks. After a successful hunt higher in the mountains the next day, the hunters could have brought their game to the cave for secondary processing, which involved cutting up the desired parts into transportable packages.

Why use mollusks as trail food? The marine limpet *Patella vulgata* accounts for more than 98 percent of the mollusks in the Solutrean occupation of the cave. This species can survive up to three or four weeks when stored at temperatures of 5–12°C if protected by a covering of damp seaweed. They could not only last at least several days on the trail but also be eaten raw. Packed away in the cave, they would also provide tiding-over food before fresh meat was obtained. The presence of seal flipper bones in level 4 is likewise suggestive: coastal Inuit peoples historically used seal flippers as a handy and nutritious trail food.

Although one is struck by the abundance of mollusk in these levels, converting this source to caloric values gives a different impression. Ortea has calculated that these specimens are relatively large in comparison to those gathered along the Asturian coast today, a difference he attributes to later systematic human exploitation. By his estimate, larger individuals from areas not heavily exploited at present have an average fresh meat weight of 11.9 grams and a dry meat weight of 3.5 grams. Applying these larger fresh meat weights to La Riera gives a minimum of 12,495 grams (27 pounds) in level 4, which would support five hunters for two days; 16,422 grams (36 pounds) in level 5, which would support six hunters for two days; 1,511 grams (4 pounds) in level 6; and 6,985 grams (15.4 pounds) in level 7. One white-tailed deer provides more calories than a metric ton of fresh shellfish meat.

The occupations in these levels probably represent brief encampments primarily for upland ibex and red deer hunting. The hunters who used them selected prime-age animals, generally targeting the largest and best nourished in the herd. Such target selection hunting strategies require a relatively accurate weapon system that employs a projectile propelled by mechanical means, such as a spear thrower or a bow and arrow. The narrow seasonal use of the cave suggests that deer and goat were hunted in the late summer and fall, when they were in prime condition, also coincident with the fall salmon runs. This repeated seasonal hunting pattern suggests that such activities focused on other

habitats during the winter through early summer, such as hunting sea mammals on the coast.

The climate shifted to a warmer, more humid phase during the last eleven Solutrean occupations of the cave (levels 7–17). At this time it was used once again as a residential location, and hunting was oriented primarily toward red deer. The majority of the animal bones are from the anatomical parts that contain high-yield muscle masses, strongly indicating local meat consumption. Although some juvenile red deer and ibex were slaughtered, prime-age adults dominated the sample. Such an age profile is not likely to result from random-encounter hunting and supports Straus and Clark's conclusion that efficient trapping techniques had been developed to capture large numbers of targeted individuals. This suggests that the Solutreans offset the effects of reduced biomass or territorial prescription by increasing their efficiency in procuring those animals still available. Such tactics would require cooperation among a number of hunters and tighter, possibly hierarchical (hunt chief, hereditary leader, etc.) social organization.

The sample size in some of these upper levels was sufficient for Altuna to assess more accurately the months during which the animals were killed, which in turn identifies the time of year and the duration of occupation of the cave. Level 7 is unique in having remains of animals killed throughout all seasons of the year. Converting the amount of meat represented by the MNI into consumption per person per day indicates that there would have been enough food for an extended family of fourteen for about a year. A group of this size would have been large enough to accomplish the tactical hunting implied by the age and sex distribution of the animals represented.

If level 7 does represent a continuous occupation that lasted for a year, there must have been an increase in fuel availability. Although the environment at this time appears to have been relatively treeless, there is an increase of roe deer in the faunal record. Since these are generally considered woodland animals, their presence may imply an increase in the amount of forest near the cave. Enhanced availability of local firewood or other fuels would have enabled a small band to occupy the cave more continuously than had been possible in earlier times.

Table 8.1 shows that the amount of time spent living in and hunting from the cave varies considerably by level. It is noteworthy that no animals were incorporated into the cave deposits, with the possible exception of levels 8–9, between mid-winter and the end of spring. This means there was no hunting here during this period and that people either hunkered down at the site or abandoned it while the winter storms raged. Frozen or dried meat from fall and early winter kills could have supported a band for a short period, masking the time actually spent in residence. We are impressed, however, by the correlation of the length-of-stay calculation and the seasonality data and therefore accept that the consumption figures tend to indicate the length of time the site was occupied. If the site's occupiers abandoned it between mid-winter and the end of spring, they must have moved to a location where resources were more abundant, such as sea mammals on the coastal ice.

The upper Solutrean levels appear to represent two residential patterns, both of which ultimately focus on red deer as the main food source. These patterns differ in use intensity and length of occupation. If the occupations were continuous, the people living in levels 7–9 may have spent up to a year at a time in the cave, whereas in levels 10–13 the stays were much shorter, averaging around three months. In those levels where it is possible to assess the seasons of occupation, they extend from spring to early summer, and the evidence from level 16 indicates that some people also stayed for a short while in early winter.

SOLUTREAN SETTLEMENT PATTERN MODELS

The geographer Karl Butzer hypothesized a multistage Paleolithic settlement for this part of Spain.[10] His model begins with the Middle Paleolithic Mousterian and traces a slow geographic change in settlement patterns that correlates with a steady increase in human populations and technological advancements. He proposes that the primary residences were initially located at a central place established in the north Spanish piedmont belt, near or along a major river and the piedmont-mountain ecotone, where people could have easy access to a variety of resources in multiple ecological zones: a group living in a camp at this location could exploit both the coast and the mountains. Each major river valley would have defined a core territory, but minor valleys might have been shared with groups on either side. When these areas became depleted, the band would simply move to another river drainage.

By Solutrean times the population had increased and both the marine and montane zones were being exploited. Multiple groups still had overlapping operational areas, but during the subsequent Magdalenian period there was a shift to both diversification and specialization, with more effective integration of marine and montane resources. According to Butzer this situation developed into two distinct systems, one on the coastal plain and the other along the piedmont-mountain ecotone. The splitting of valleys into these two resource areas would have been particularly adaptive as the number of competing groups increased. The coastal population would have become more dependent on marine resources, requiring higher labor input but producing fairly predictable yields, while the inland groups would have relied on game trails, especially during periods of reindeer migration. The importance of this last phase of Butzer's model is that it would have accommodated a doubling of the human population in the area.

Straus, in a model similar to Butzer's, views the Solutrean settlement pattern as a central-base foraging system with increasing emphasis on aquatic resources, and from La Riera he estimates an average two-hour walk to and from the coast.[11]

From our examination of the cave evidence, we generally concur with the original investigators that the occupations can be divided into three groups based on length of residence, types of activities, and animals targeted, but in light of these models we offer the following observations for consideration.

Levels 2–3 are the earliest Solutrean occupations of La Riera, and because of the way the cave was used they stand out as different from the levels that follow. In fact, despite the presence of several key Solutrean artifact types and evidence of a shift in the selection of raw material sources, the hunting strategy associated with these levels appears to be more like that of the earlier Aurignacian people than of the later Solutreans. We suggest that these earliest hunters foraged around and from a central base residential camp, in this case La Riera, and killed animals as they encountered them, without targeting specific species or ages. When the local resources were depleted the band moved on to occupy another area.

This settlement behavior is compatible with Straus's interpretation and is the overlapping operational stage of Butzer's model, in which the local band shares resource areas with neighboring groups. Our conjecture is that these undated occupations occurred early enough in the LGM that its climatic changes and the increased population had not yet impacted resources in the Vasco-Cantabrian area, where it was business as usual.

After the onset of the cold, dry period, population pressure began to reduce the size of territories and bands started establishing semi-permanent base camps in strategic locations near more reliable resource areas. Working out of their home base, these foragers used short-term occupation sites in task-specific localities and returned home with whatever goods they acquired during the trip. Levels 4–6, the specialized ibex and red deer hunting camps recognized by Clark and Straus, are clear examples of the use of La Riera as a temporary shelter for staging task-specific foraging trips. The mix of shouldered projectile points and indented base projectile points may indicate that at least two different contemporary social groups used the cave.

We suggest, on the basis of the thinness of the occupation lenses, that these levels were produced by small subsets of extended family groupings, perhaps consisting of only male hunters on two-to-three-day trips. The fish remains also suggest that many of these trips were late summer or fall excursions, when the salmon and sea trout were spawning. At the cave the hunters either consumed or filleted the fish whose remains were recovered from the occupation levels, while they perhaps dried or smoked other fish and took them back to a base camp along with selected high-yield food packages.

Because of the dramatic appearance of aquatic resources such as shellfish, fish, and seal, we propose that semi-permanent base camps for the La Riera hunters were downstream and near the beach or estuaries (figure 8.2). Campsites in sheltered localities near these environments would have had many advantages over upland campsites, including relatively continuous opportunities to obtain high-yield resources such as fish, waterfowl, and some sea mammals. Shellfish would be a great resource when found near a campsite, whereas their advantage would ebb exponentially when transported many kilometers. Another direct advantage would be the possibility of collecting driftwood that ends its long journey from southeastern North America tossed by storms onto the beaches of the Bay of Biscay.

The adjacent continental shelf was a vast plain and an excellent habitat for herd mam-

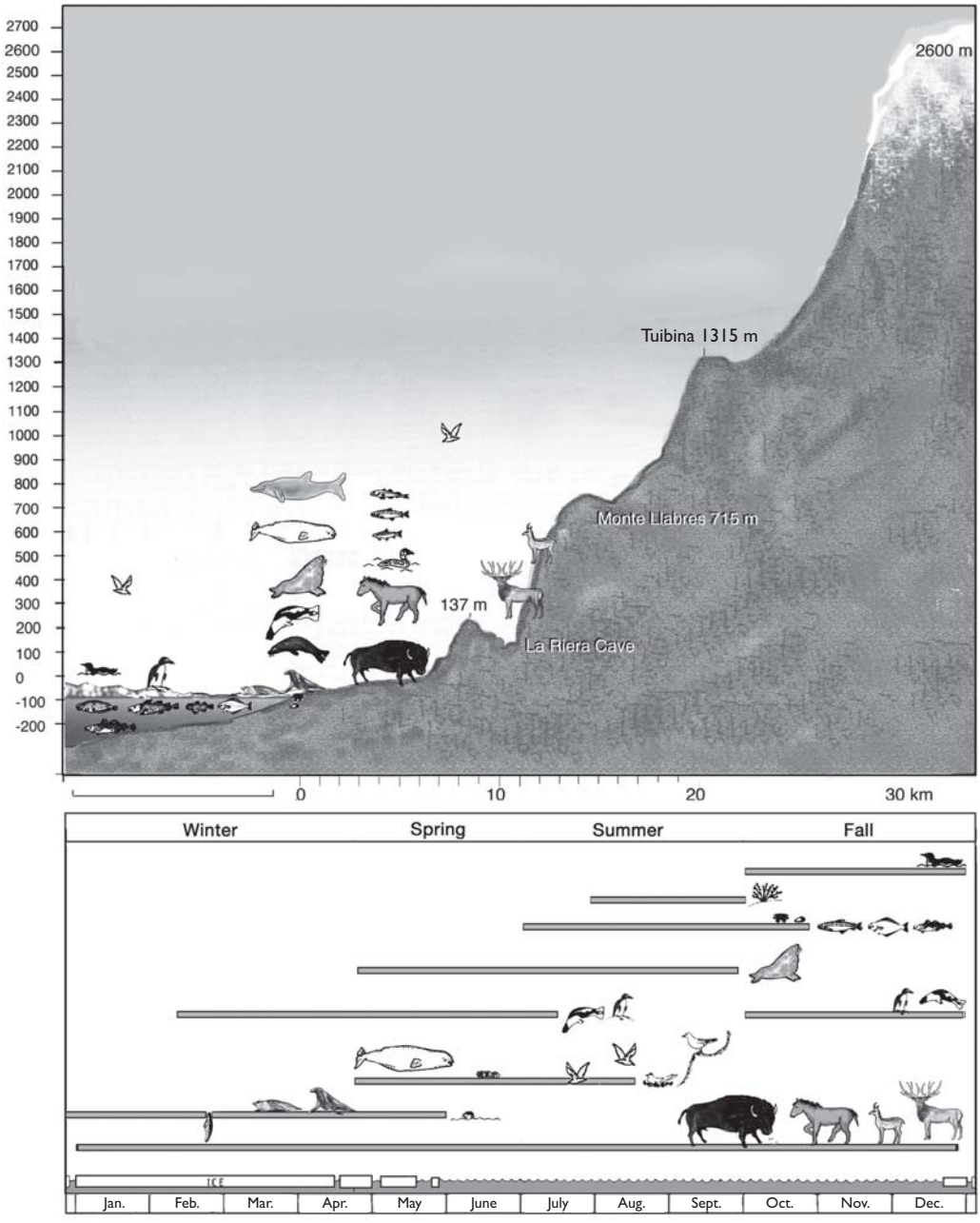

FIGURE 8.2.

Ecological zones where the highest-return resources were available throughout the year.

mals that, along with the abundant coastal and marine resources, would have provided food for people living on the coast. In fact, for bison and horses this cold dry, steppe environment would have been much superior to the unstable, steep slopes and deeply incised valleys of the Cantabrian piedmont. Bones from dredging operations in the North Sea and English Channel indicate that mammoth herds and other extinct animals also grazed on the plain.[12]

If semi-permanent camps were in prominent coastal locations, they could have enhanced inter-band social contacts between areas of southern France and Iberia. Here we see the effects of two important terrain-dependent aspects, visibility and accessibility. First, people would have been much easier to find camped at prominent sites along the beach than hidden away in the broken topography and deeply incised countryside of the piedmont and mountains. Second, the continental plain would have been a virtual inter-area autobahn connecting groups from Asturias to the Aquitaine and beyond. Trails on the plain would have been far superior for travel than the seesaw trails up and down the steep and unstable slopes of the high ground and over-mountain passes that were seasonally blocked by snow and ice—although except when the plain's rivers were frozen over, some sort of watercraft would have been desirable to manage their crossings.

In terms of Butzer's model this period represented a transition from the early overlapping operational central place pattern to the beginnings of a regional specialization phase. Although there was probably still overlapping use of neighboring territories, extended kin networks or other alliances would have socially formalized the use of these areas. In levels 4–6 the settlement system would have included entire drainage areas, from the shoreline to the snow line. Once a base camp was established, upland hunting would continue, but on an ad hoc basis and probably highly related to seasonally specific tasks such as fall hunts, when red deer and ibex were in prime condition.

We agree that the last series of occupation levels (7–17) shows that the cave was again used primarily as a home base, but here the pattern of use was more complicated and variable than in levels 2–3. The refuse midden of level 7 is large enough to suggest a long-term encampment. It appears to be related to the previous three levels in that it maintains a strong component of both estuarine and riverine resources, as well as shared artifact types. It differs in the development of intensive red deer hunting, suggesting another change in the social, settlement, and procurement systems of the valley brought on by a climatic shift, loss of some maritime species, economic specialization, or perhaps continuing population increase.

By level 7, we think, the population had increased to the point of beginning the "fission" stage of Butzer's model, when the semi-related group of people (a band) separates into distinct inland and coastal groups. It is clear that bands at this level were beginning to use the piedmont and lower foothills for more extended periods of time or even on a semi-permanent basis. From level 7 up, with the exception of a period between levels 10 and 13, the duration of camp activities seems to range from eight or nine months to perhaps a year.

There is, however, a period from mid-winter through spring when the cave seems to

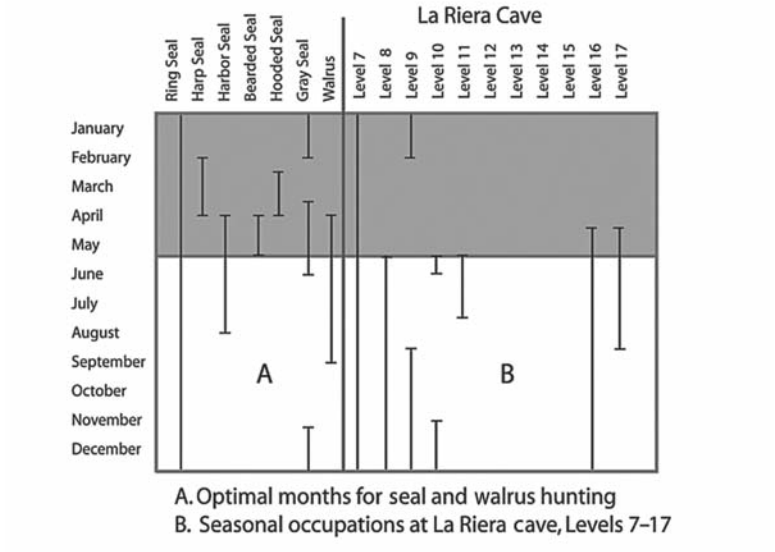

FIGURE 8.3.
Seasonal chart of seal and walrus presence on the northern Spanish coasts and La Riera Cave use in Solutrean times.

have been abandoned by all later Solutrean people—oddly enough, corresponding to prime sealing months. In 81 percent of the Solutrean occupation levels for which there are seasonal data, the caves appear to be abandoned during the time when seal hunting would have been optimum on the coast. Figure 8.3 compares the calculation of seasons of the upper Solutrean occupation of La Riera Cave with periods of seal vulnerability (the birthing schedule of seals that live on the ice edge is regulated by seasons, so that pups are weaned by the time the ice breaks up in the spring). This correlation is highly suggestive that inland groups of Solutrean hunters moved down to the coast for several months during late winter to participate in sealing and probably provided the coastal people with mountain products such as ibex, chamois, and roe deer meat and durable goods. For the coastal group, most seal hunting could have taken place anytime there was sea ice in the neighborhood, either landfast or floating. Plus, the harbor seal was a year-round coastal resident and could be hunted during the summer, when sea ice was absent.

Perhaps we are seeing evidence of a settlement pattern similar to that of the Inuit of northwest Alaska. There the coastal and inland populations generally operate independently, but during certain seasons of the year the inland groups go to the beach for trading, hunting, and other social activities with their coastal relatives (a periodic regional aggregation group, in Binford's terminology). We contend that this would have been part of a natural progression leading to Butzer's adaptive divergence stage.

Both Butzer and Straus make passing mention of a possible Solutrean coastal adaptation, but they do not seriously consider it while model building because there is no proof. Based on the hard data available, it would indeed appear that economic intensification

and integration of marine and montane resources began during the Magdalenian, but we think this reflects archaeological invisibility caused by the post-LGM sea level rise rather than a difference in cultural development.

This point is illustrated by Darrin Lowery's work on Late Woodland occupation in the watershed of Chesapeake Bay in North America.[13] The eastern shore of the bay includes large estuarine sites with dense shellfish refuse and ample evidence of the use of other marine resources, as well as interior hunting-oriented sites with limited debris. The interior sites are generally located near freshwater springs that had been attractive to hunter-gatherers since Paleolithic people settled in the area. If global warming were to cause today's sea level to rise 2 meters, the Late Woodland sites with marine refuse middens would disappear and there would be no archaeological record of the use of marine resources. The settings of the surviving terrestrial Late Woodland sites would mimic the settings of the European Paleolithic sites and provide fewer clues than exist at La Riera to indicate that the Late Woodland peoples gained most of their resources from the bay and ocean. Similar situations exist in many other places in the world where sea level rise or coastal subsidence has wiped out entire components of prehistoric settlement systems.

We assume that, like the Late Woodland fishing folks, most prehistoric people operating out of semi-permanent base camps did not carry marine hunting and fishing equipment with them while exploiting upland terrestrial environments unless it was multifunctional, such as spear throwers and darts, which are effective on both open land and water. Bows and arrows and self-barbed lances are also effective in a variety of hunting and fishing environments. Boats and toggling harpoons, on the other hand, would have been left behind.

We would not normally expect to see marine food items carried any great distance from the coastline. In an excellent summary article of the issues involved with archaeological evidence for aquatic adaptations, Jon Erlandson points out that when modern hunters-gatherers forage beyond their base camp for 5–10 kilometers, they do not usually transport the skeletal remains of shellfish, fish, or sea mammals back to their residential camp.[14] Therefore, sites located more than about 5–10 kilometers from an ancient shoreline are not likely to contain substantial evidence of marine resource use, and even in sites as close as 1 or 2 kilometers from shore the density of aquatic remains drops significantly. The exceptions to this are marine mammal ivory and teeth that were used for adornment. These specimens can be transported great distances from the coast and were traded to remote interior peoples. Levels 4–6 at La Riera Cave contained a remarkable amount of estuarine and marine remains considering the cave's location in an upland setting and its distance from the coast.

TECHNICAL INNOVATIONS

Clark and Straus illustrate resource intensification beginning in Solutrean times with the development of technical innovations to increase hunting efficiency.[15] Among the new

technologies they consider are decoys, nets, movable fences, and weapons such as spear throwers and possibly bows and arrows. All of these hunting aids would have been made of perishable materials (e.g., wood, plant fiber, animal tissue), which are usually not preserved in archaeological contexts. Except for evidence such as spear thrower parts recovered in excavations and their depictions in rock art, the use of these new hunting technologies by Solutrean people remains in the domain of speculation. But since the number of new artifact types found in Solutrean sites is relatively extensive, it is clear that these people were heavily invested in research and development (see chapter 5). It seems probable, therefore, that they developed and used not only these hunting aids but also myriad other tools and exploitive and protective systems for which there is no direct evidence. This would be especially true of equipment for the exploitation of marine resources, which was likely stored at campsites near beaches long ago destroyed by sea transgression.

All of the available evidence suggests that European Paleolithic armaments prior to Solutrean times consisted primarily of thrusting and casting weapons. A wide variety of new projectile point types and several new weapon systems first appear during the Solutrean and are suspected by Clark and Straus to be the result of experimental efforts to develop more efficient means of killing game as a response to population increase. Although this may have been true, we think the situation was more complicated and that several issues directly related to climate change should be equally considered as part of the impetus for the development of new hunting gear and techniques. Perhaps the diverse varieties of the projectile point types seen during Solutrean times were experimental prototypes, many of which were abandoned through time.

The Solutrean people were among the first modern humans to face a glacial period in Europe, and climatic change, especially associated with deforestation, would have had a direct impact on their hunting techniques and available raw materials. The loss of forests and redistribution of animals would have greatly diminished the opportunities for ambush hunting such as seen in levels 2–3 of La Riera Cave. Instead of a multitude of places along game trails in the woods, there would have been fewer locations where hunters could hide. Game stalking would have become a fine art as opportunities to get close to targets were greatly reduced. This would have been especially true on the vast plain of the continental shelf, which became a mecca for ungulates. An additional stress resulting from the loss of the forest environment would have been the dramatic decrease of wood for tools, especially long straight spear shafts, and for fuel. It is probable that driftwood cast up on the ice age shores augmented the supply of wood from the rare and scrubby native trees.

Developing accurate long-range shooting equipment for hunting in an open steppe environment would have been necessary, in addition to learning completely new sets of hunting skills. The formation of large, organized groups of hunters for animal trapping and manipulation would have provided an advantageous edge for survival during these times. All of these innovations, necessary to efficiently exploit the newly emerging open steppe, would have been equally adaptable to hunting ice edge environments.

The simple sharp-pointed thrusting spears used by humans throughout the majority

of our time on earth were improved. New weapons had multiple parts, including foreshafts, with socketed projectiles to which end or side blades were attached. The least complicated of these innovations were thrusting spears with a projectile point made of flaked stone, bone, antler, or ivory.

More complex systems were developed with shaft modifications that accommodated new propulsion methods suited to the new hunting situations. These included darts cast with throwing boards and arrows shot by bows. The latter are conjectured based on the size of single-shouldered points and on small-stemmed projectile points found primarily in southern Spain and Portugal. The simple thrusting spear was further improved by the attachment of a self-barbed spear point (see figure 5.4a).

All of these systems have different and multiple hafting arrangements, including rigidly mounted points and detachable, interchangeable, and replaceable parts (figure 7.5). Multiple components can include a blade set into a harpoon-like socket, the latter either firmly fixed to the foreshaft or designed to break apart from it on impact. Likewise foreshafts and shafts could be firmly fixed together or designed to break apart on impact. All of these systems might or might not have had cords or lines attached to either the blade socket or the foreshaft. The advantage of the line is that it allows the hunter to hold onto the shaft or attach the weapon tip to a weight or float. When an unfortunate beast reaches the end of the cord, either it is held fast or the weapon tip is torn from its body, causing an ugly, lethal wound. Attachment accommodations are most important for aquatic hunting, since they provide for the retrieval of dead or wounded animals before they sink beneath the water. It is thought that line holes drilled through Magdalenian harpoon heads represent the beginning of aquatic harpoon technology.[16] However, lines were not that necessary during the LGM, since the elevated salt content of the seawater kept mortally wounded animals from sinking rapidly. Retrieval could have been accomplished in many ways, including boating out, casting a grappling hook and line, or simply waiting for the animal to drift ashore.

Perhaps as important to Solutrean hunters as the efficiency of the new weapons was the fact that these break-apart systems allowed for the retrieval and long-term survivability of spear shafts. Because of the deforestation of the Spanish countryside during the LGM, long pieces of wood suitable for spear shafts were likely rare. Even before then, from searching for suitable pieces of wood to shaping and straightening, shaft construction was a major time-consuming process. The development of detachable foreshafts likely saved many a spear shaft from ruin and allowed the hunter to retrieve the shaft. This was a particular novelty in aquatic environments. Such systems also allowed hunters to re-arm with a new weapon tip and take additional shots at other targets. Consequently, we agree with Straus that Solutrean hunters used foreshafts, and we propose that some of the bone and antler rods with blunted or rounded distal ends were probably used as foreshafts rather than projectile points.[17]

A relatively wide variety of stone and bone artifacts found in Solutrean sites have been identified as projectile points. These include unifacial and bifacially flaked stone points

of various shapes, such as laurel leaf, willow leaf, shouldered, concave base, and tanged, as well as several kinds of bone and antler points with hafting arrangements and modifications for the insertion of stone side blades. Some of these point types may be associated in the same occupation levels in various sites, but the variety of point types and number of forms vary in different areas and throughout time. Thus, Solutrean occupations can be distinguished by having some point types and not others. Part of this variation is probably temporal, but some of it may be ethnic, with overlap resulting from contact between regional bands or from population movements. It is also possible that different point types correspond to weapons used for hunting specific types of game.[18]

The self-barbed spear point and the indented base point first appear at La Riera in level 4, the beginning of the second phase of the Solutrean occupations. Self-barbed spear points are slightly curved bipointed bone or antler rods that are flattened and scored on the curve's outside surface so they can be hafted to a spear shaft with both ends of the point exposed (figure 5.4a). The leading point is for penetration, and the trailing point acts as a barb to attach the weapon securely to the prey so it can't drift away or sink. The presence of self-barbed points and fish remains in Solutrean levels, combined with the fact that similar weapons are still used by various groups for fish spearing, makes an excellent case for Solutrean people's using these artifacts in the same activities. This type of spear would have been equally effective for hunting seals at breathing holes and serves the same function as a metal sealing pike.

Straus has suggested that indented base projectile points (figure 5.10) and end blades were used on regular thrusting spears, while small single-shouldered points were used on the slender shafts of darts cast by spear throwers or on arrows (figure 5.6c).[19] In a sample of 100 shoulder points, he found an average maximum width of 1.37 centimeters with a standard deviation of 0.30 centimeters, while 45 concave base points had an average width of 2.29 centimeters and a standard deviation of 0.42 centimeters. These differences in width support the notion that the two types of points were indeed hafted differently.

To examine this idea, we compared Straus's measurements to those calculated for triangular stone points from Late Prehistoric sites along the California and Oregon coasts. At these North American sites, arrows and harpoons were used to hunt terrestrial and aquatic mammals, respectively. In a study of West Coast projectile points, Lee Lyman, Linda Clark, and Richard Ross found that arrow points with small concave bases have an average width of 1.42 centimeters with a standard deviation of 0.22 centimeters.[20] Larger concave to straight base points—which were used as tips for bone or antler harpoons when hunting sea mammals, according to native informants—averaged 2.95 centimeters with a standard deviation of 0.33 centimeters. These figures compare favorably to both Solutrean point styles in Straus's theory, supporting his idea that the narrow-shouldered points were used on arrows or narrow dart shafts and the broader concave base points on heavier spears. (Such heavier spears may well have been tipped with harpoon-like sockets armed with end blades.) The theory is further supported by the coastal distribution of Solutrean concave base points (figure 8.1).

In summary, it appears that most of the new weapon systems developed during Solutrean times were ideally suited for open steppe and aquatic hunting. Among the innovations for which there is tangible evidence are spear foreshafts and harpoon-like end blades; both strongly imply that Solutrean hunters used detachable end blade sockets, which are found in most if not all primitive marine mammal hunting tool kits. Further, the self-barbed spear is an unquestionably aquatic hunting adaptation that historic northern Europeans used for hunting seals at breathing holes. Although the presence of these weapons does not prove that Solutrean peoples hunted marine mammals, it does mean that they had developed the equipment to do so, and there is no reason to suspect that they would not have thought it a good idea—especially while visiting the coast during the prime seal-hunting months.

Inasmuch as the evidence suggests that Solutrean culture existed for some 3,500 or more years and that during most if not all of this time a major part of their settlement system was directly adjacent to or at least in view of the ice age sea, we consider it entirely unlikely that these acknowledged great innovators would not have learned to understand and exploit this environment. In fact, it is possible that many of the innovations with which they are credited were the direct result of a maritime adaptation.

9

THE LAST GLACIAL MAXIMUM

How Bad Was the Weather?

The ice age world in which the Solutrean people lived had climatic conditions so different from ours that they are difficult to imagine. Our modern circumpolar regions might serve as analogues to provide us hints about surviving in such conditions, but we must be aware of the major differences from even these Arctic backdrops. For instance, a whole host of now-extinct animals, such as mammoths, mastodons and saber-toothed lions, lived side by side with early humans. The LGM climate caused the formation of huge ice caps that covered more than half of the Northern Hemisphere and were several miles thick in some places. This accumulation of ice reduced ancient sea levels by hundreds of feet, expanding continents and exposing new lands for plants, animals, and people to colonize.

These events produced an environment that although not idyllic was understood and exploited by those peoples who lived during the LGM. It is under these radically different conditions that we hypothesize Solutrean people adopted a maritime economy and, while exploiting marine resources, crossed the Atlantic.

PALEOCLIMATOLOGICAL MAPPING

To understand the Paleolithic world, scientists have reconstructed past environments on the basis of fossil plant parts and pollen found in archaeological sediments and extracted from cores of dated sediments taken from lakes and bogs. Modern plant and animal communities can provide analogues for the extinct Pleistocene species found in Paleolithic sites, and their environmental requirements can be used as proxy indicators of past environments. After many years of research aimed at deciphering past environments, we

are only now beginning to understand how complex and interconnected the web of natural phenomena was that shaped the ice age world.

During the 1970s a large-scale program known as CLIMAP (Climate: Mapping, Analysis, and Prediction) was established to synthesize oceanographic paleoecological data and produce models of past climates that would explain why climates change and thus help us to understand our present climate better, as well as predict the climatic events of the future . . . such as global warming.[1] The CLIMAP project was so successful that it stimulated another project, COHMAP (Climates of the Holocene—Mapping Based on Pollen Data), which had the same objectives but concentrated on terrestrial paleoclimatic data.[2] Another project, known as EPILOG (Environmental Processes of the Ice Age: Land, Oceans, Glaciers), was established in 1998 to assess the advances made during the preceding twenty years of paleoclimatic research.[3] The goals of this project are to find points of consensus, resolve conflicts in data, set standards, and outline a plan for a new synthesis of evidence about the LGM.

Because of these and related projects, our ability to refine our interpretations of these early environments has improved dramatically, and we are able to draw an increasingly accurate picture of past climates.[4] The important sources for climatic data come from studies of ice cores pulled from the Greenland and Antarctic ice caps and deep-sea cores taken from sediments deposited on the ocean floors. Refined techniques for analyzing pollen from lake, pond, and marsh sediments also sharpen our interpretive abilities. The principles underlying these methods are similar to those applied to lake varves, the layering of successive soils from storms deposited in the bottom of a lake that reveals climatic events that occurred in that local area. Ice cores are the best source of data for the climatic history of the Northern Hemisphere, for they provide a continuous record of annual and seasonal ice deposition. Each layer is like an entry in a diary, documenting worldwide events ranging from rainfall to volcanic eruptions.

Sediment cores taken by drilling ocean floors are being correlated with the Greenland and Antarctic ice cores to provide an even more refined record of past climatic events and a wide variety of other phenomena that aid in the interpretation of global climatic history. For instance, mapping the presence of specific rocks and debris released by melting icebergs and preserved in deep-sea cores across the ocean floor can identify the location and direction of flow of ice age ocean currents. Dust and rocks were incorporated into the ice as glaciers cut through the continental landforms. When the glaciers eventually reached the sea, large chunks of ice broke away, forming icebergs. As these floated along on ocean currents, they melted, leaving a trail across the ocean floor of fine dust particles, rocks, and debris, along with their trace element signatures. Scientists refer to this material as ice-rafted debris, or IRD. Melting icebergs from northeastern Canada carried debris consisting of limestone from that area, bergs from Iceland contained basaltic glass, the IRD from the British Isles was composed of chalk, and so on. When IRD is correlated between cores, it identifies the routes the icebergs followed and provides maps of the courses of the ancient ocean currents (figure 9.1).[5]

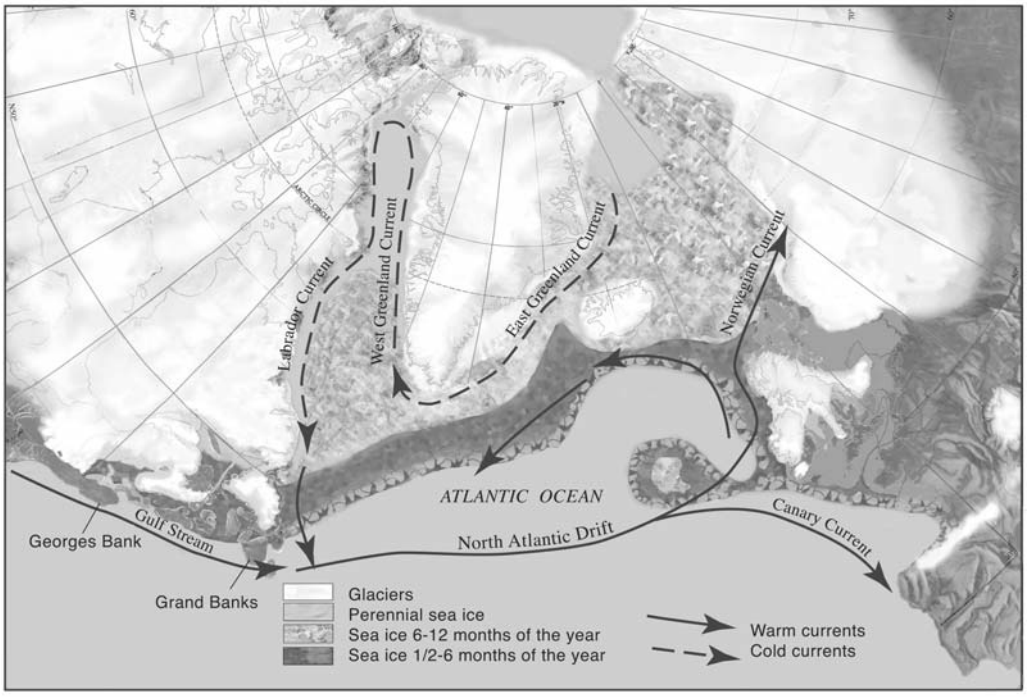

FIGURE 9.1.
Reconstruction of primary ocean currents and the North Atlantic sea ice cover during the Last Glacial Maximum. (Based on de Vernal and Hillaire-Marcel 2000; Dyke and Prest 1987; Lambeck 1995; Pflaumann et al. 2003; Preece 1995; Rida and de Vernal 2008.)

Calcareous oozes on the ocean floors contain the remains of tiny marine organisms such as coccolithophorids, diatoms, dinoflagellates, foraminifers, and ostrocods, among others that once lived in the waters above. After dying they sank to the bottom of the ocean and were buried in the ever-growing ooze deposit. When extracted in a deep-sea core, their fossil remains enable scientists to estimate past sea surface temperatures, sea level changes, and volumes of land ice, among other phenomena.

We know the environmental tolerances that control where these organisms live today, and the ratio of oxygen isotopes in their skeletons correlates with seawater temperature changes.[6] Isotopic analyses of each foraminifer species in a deep-sea core are plotted against their depth in the core to provide a record of changes in water temperature. *Neogloboquadrina pachyderma* signals the coldest water; hence when it is highly abundant in a core it is thought that the sea surface temperature above was cold (figure 9.2). The time-transgressive isotope curve can also be used as a proxy index of global sea levels, with maximum peaks representing warming periods and minimum peaks representing cooling episodes, during which ice sheets grew and global sea levels fell. The warm stages have been given odd numbers and the cold periods even numbers. The information so acquired makes it possible to reconstruct past ocean environments and their productivity, which

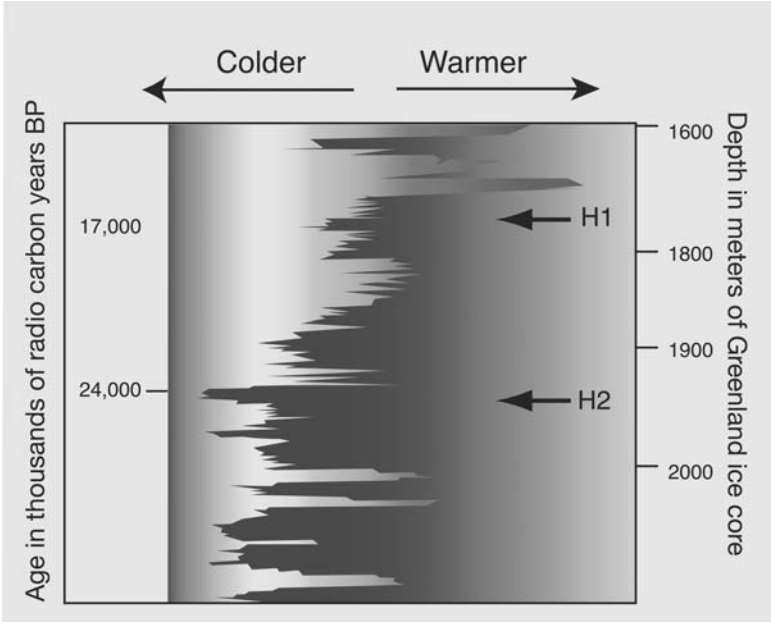

FIGURE 9.2.
LGM cooling and warming trends as reflected in the Greenland ice cores. Temperatures changed relatively often and the LGM Ice Age was not a event, but a complicated process during which the Polar Front moved southward during colder periods and northward during warmer periods.

in turn tells us what sea organisms could have survived in these polar and subpolar marine environments.

Paleoclimatological mapping has produced some surprising results. We have long talked about four ice ages.[7] It is now apparent that multiple events during the Pleistocene represented long-term cooling trends, known as Bond cycles, and incorporated many shorter ice advances that alternated with periods of warming.[8] Heinrich events, named for Hartmut Heinrich, were periods when massive amounts of ice calved off glaciers and formed huge packs of icebergs.[9] Although we once thought that creating an ice age took millennia, we now realize that drastic climatic change can happen extremely rapidly, perhaps even within a few decades.[10] Climate change is a highly complex phenomenon that is affected by a vast network of processes, events, and relationships as yet incompletely understood. Science has made great strides in the past few years in determining the nature of our planet's past climates, and future research promises to refine these interpretations.

The following discussion represents our synthesis of the climates and environmental changes during the LGM. We are primarily interested in the data from the interval encompassed by Heinrich events H1 and H2 (16,000–24,000 years before the present). Within these stages, cycles, and events there were many rapid and longer-term fluctuations in the climatic parameters, which required our Paleolithic ancestors to develop a

broad range of survival skills. Some climatic episodes would have been more hospitable to land and maritime resource exploitation, others less so.

LGM OVERVIEW

During the LGM temperatures in the high-latitude Northern Hemisphere dropped to an unprecedented low. Snow and ice accumulated until they formed massive glaciers in the high elevations and latitudes around the world. Two major glaciers developed in North America: the Laurentide centered on Hudson Bay, and the Cordilleran formed in the Cascade Mountain Range of British Columbia.[11] These glaciers began to develop more than 24,000 years ago and expanded outward from their centers. Their margins eventually collided along a roughly north-south axis from the Yukon to southwestern Alberta, forming one solid ice cap over the top of the Americas that lasted nearly 8,000 years. These glaciers began to recede after the LGM, opening an ice-free corridor. Eventually their remnants existed only in higher mountain valleys and other minor locations in Canada and Alaska. Glacier National Park contains some of the last southern traces of the LGM ice fields and serves as a reminder that these climatic episodes are not static events but ongoing processes.

The Fennoscandian Glacial System developed in northern Europe, spread westward to the North Sea, and pushed southwest toward the Saône River in France (figure 9.1). It also grew east- and southward, combining with smaller local glaciers to cover the top of the continent and uniting much of Europe and Asia under a single massive ice cap. A smaller glacial system, the British and Irish Ice Sheet blanketed the British Isles except extreme southwest Ireland and parts of southern England.[12] Many smaller glaciers also developed in the Alps, the Pyrenees, the Picos de Europa, the Brooks Range in North America, and elsewhere. But they played their part: although the Greenland Ice Sheet was relatively small in extent, it was more than 3,000 meters thick.

These ice fields, along with others around the world, captured so much of the earth's available water that the sea level dropped an average of 130 meters. This exposed the continental shelves, creating land bridges that connected continents to continents and islands to continents, providing new lands and pathways to be exploited by both humans and animals.

SOUTHWEST EUROPE IN THE LGM

When the sea level dropped it revealed countless square kilometers of continental shelf around the world. In Europe, for instance, the French Aquitaine shoreline was extended more than 50 kilometers beyond the present coast of Europe, exposing approximately 20,000 square kilometers of low-lying, rolling limestone hills. Along the Cantabrian coast of Spain a narrow continental shelf extended the coastland as much as 10 kilometers farther out to sea. And like western Beringia and North America, the unglaciated southern

portions of Ireland and England were joined to continental Europe by a vast land bridge (figure 5.3).

This bridge was a low-lying plain with bogs and ponds, interrupted by a river system that drained northwestern France and southern Britain.[13] Glacial silts and sands moved through this drainage system to be deposited into the sea at the rivers' mouths. The sands that washed along the coastline were spread out along the beach and in some regions built dune barriers that provided areas of quiet waters, which allowed the development of estuarine and shallow sublittoral environments. Much of this sediment was eventually carried by strong winter winds back across Europe, covering a great deal of southwest France, known as the Landes. Dunes were common features along these shorelines; the Dune du Pilat near Bordeaux, the largest sand dune in Europe today, is a reminder of this ice age process.

Karl Butzer has estimated that July temperatures in western Europe were as much as 10°C lower than they are today, drastically affecting the entire ecosystem.[14] He has suggested that most of the interior of the Iberian Peninsula suffered significantly, as cold temperatures made even more severe by dry cyclonic winds blowing across the glaciers significantly lowered the productivity of the plains of Spain. Butzer also characterized the environment as an arctic steppe biome, where few plants grew and large herds of herbivores could not be sustained. As a result of these weather conditions, most animal and human populations moved to areas with more temperate climates. Pollen records and the increased number of archaeological sites indicate that more favorable conditions existed along the coastal areas of Spain, Portugal, and southwestern France and in the sheltered river bottoms of southwestern France.[15]

Within 35 kilometers of the ice age shore, the Picos de Europa tower 2,500 meters above the north coast of Spain. The Picos and the narrow coastal plain are separated by a series of increasingly higher east-west trending mountain ranges. Each mountain range supported a unique ecological system with a diversity of natural resources. Along the coastline a succession of estuarine zones and river valleys led back into the piedmont, a narrow plateau, offering their own resources and providing relatively easy access and short travel distances to the uplands. Paleolithic peoples, perhaps operating from camps close to a variety of different ecological zones, could have exploited resources in each of these zones, taking advantage of seasonal concentrations of natural resources, such as game and berries.

Butzer thinks northern Spain was a relatively treeless, steppe-like environment dominated in higher elevations by grasses and sagebrush. But because of its maritime character, the climate here would have been less cold and snowy than in the interior and less prone to bouts of severe weather. The ground cover at lower elevations was probably grasses and ferns, with heath plants in open windswept coastal regions. High counts of arboreal pollen suggest that locations sheltered from the wind protected small stands of trees, especially during warmer episodes. Pine, oak, and hazel trees may have grown on

sheltered slopes with southerly exposures, and stands of alders along stream margins or floodplains.

Spain's high-mountain topography was probably mostly barren and snow-covered throughout the year, with many upper valleys glaciated. The tree line was around 1,600 meters high. At lower elevations, beech was the most common tree. Deciduous oaks extended up to 1,100 meters on relatively dry northern slopes. The Pyrenees were a formidable barrier between northern Spain and southwestern France. Its deep, ice-filled intermontane valleys would have provided few access routes, the most important of which may have been along the now submerged continental shelf.

Beyond the Pyrenees the gently rolling countryside of the Aquitaine Basin gave way to the Landes region, where sands deposited during and after the LGM now cover the Paleolithic topography. In the central part of southwestern France the long, sinuous river valleys that snake around the hills of Dordogne dissect the Perigord region. These river valleys provided limestone caves and rock shelters that offered refuge to Solutrean bands, as well as numerous outcrops of readily chippable stones. The upland interior plateaus were more open landscapes with full tundra vegetation, but because the valleys were sheltered from the period's full climatic rigors they preserved zones of protected forest.

Bones found at archaeological sites indicate that the nonmigratory red deer was the animal most commonly hunted by the Solutrean people in northern Spain. Although generally regarded as woodland animals, red deer can survive in open grass-heath environments such as existed on the coastal plain of northern Spain. In fact, the bones of the Spanish red deer are relatively large, meaning that these animals made out quite well on the available forage. Horses and bison were hunted along the coast and in the broad river valleys. The remains of ibex and chamois, hunted on the mountain slopes, are less numerous, and there are only occasional traces of roe deer, boars, and various birds. Giant deer, woolly mammoths, steppe rhinos, musk oxen, steppe antelope, and bison are also insignificant in collections from Solutrean middens, although their remains have been dredged up from the submerged continental shelf, and they are depicted in cave art.

Moving northward through the Basque country, reindeer become more common in faunal assemblages, and by southwestern France, where there were more snowfall and wet meadow habitats, reindeer replace red deer as the primary prey of Solutrean hunters. At the site of Solutré, just west of the Saône River in east-central France, an overwhelming amount of reindeer bones identify the Solutrean occupation as a typical specialization hunting site.[16]

The extent of Solutrean use of the continental shelf is unknown at present. Its probable importance has been summarized by the archaeologists J. Rigaud and J. Simek: "Between one- and two-thirds of the land surface available in Late Pleistocene Aquitaine now lies buried either beneath the sea on the continental shelf or under the vast sand mantle of the Landes. . . . Models for Paleolithic demography, settlement systems, and subsistence that do not consider this full range of past environmental variability, including the now-buried regions, simply cannot be taken seriously."[17] This warning is equally valid for the

Cantabrian continental shelf. Unfortunately, such models must be designed on the basis of indirect evidence and intuition and are therefore, like this study, informed speculation.

There is no doubt, however, that Solutrean people used marine resources and were well aware of the richness of the seas. Shellfish remains collected from the extensive beaches and estuarine zones of the ice age coast have been found at several Solutrean sites. At La Riera Cave, for instance, nearly 10 kilometers inland from the beach, some Solutrean occupation levels contained abundant limpet and periwinkle remains.[18] Salmon and trout have been found in faunal assemblages, as have a few seal bones. Since there is no contemporaneous evidence of boats, fishhooks, or harpoons, the seal bones are thought to have come from beached animals—but we argue otherwise in chapter 8.[19]

A tremendous number of animals inhabited the Bay of Biscay whose remains have not been found in Solutrean archaeological levels. These include walrus, several varieties of whales, and six species of seals. The last were probably the easiest to capture and could have been one of the largest food sources for Paleolithic people on the coast of northern Spain. Of the seal species likely to have been encountered in the LGM waters off the Vasco-Cantabrian coast, the hooded seal *(Cystophora cristata)* and the bearded seal *(Erignatus barbatus)* are migratory, whereas the ringed seal *(Phoca hispeida)*, harp seal *(P. groenlanica)*, gray seal *(Halichoerus grypus)*, and common (or spotted, or harbor) seal *(P. vitulina)* are resident.[20] Only the four resident seals have been found in the middens created by Late Stone Age Europeans.[21]

How far inland should we expect to find evidence of marine exploitation? In other places where the ancient shoreline is now submerged, the answer is, not very far.[22] Most Late Pleistocene sites now on or near the modern shoreline were 10–100 kilometers inland at the time they were occupied. Some have yielded the remains of fish and shellfish, but the quantities involved are very small.[23]

In summary, the LGM climate of the north coast of Spain and southwestern France was much colder and drier than at present, but the relatively high insulation, ample winter daylight due to a relatively low latitude, and moderate snow cover favored rangeland productivity and supported a reasonable animal biomass. According to the geographer Karl Butzer, from a hunter's perspective this was a very good environment, not a marginal one, with a diversity of dependable and concentrated resources.[24]

NORTH AMERICA IN THE LGM

On the other side of the Atlantic, the continental shelf of eastern North America is a huge geographic feature. It stretches along the Eastern Seaboard from the Grand Banks of northeast Canada southward to the Straits of Florida and in places reaches 400 kilometers beyond the present shoreline. Conservative calculations estimate that when the continental shelf was fully exposed during the LGM, it added approximately 445,000 square kilometers of land to the American continent (figure Intro.2).[25]

Estimates of the amount of the shelf that was exposed by the lowered sea level have

changed several times during the past fifty years.[26] How much of it was covered by ice would determine how far north and west early sea travelers could have made landfall. The map we used shows that during the LGM many coastal stretches of the eastern Canadian Arctic remained ice free and provides evidence of ice advances extending farther out to sea to pre-LGM glaciers.[27] This scenario would allow early sea travelers to have made summer landings on the shores of the Grand Banks.

In this reconstruction the North Atlantic shelf was a low-lying coastal plain intersected by glacial ice lobes and various drainage channels, of which the Laurentian Channel would have been the most impressive. Lobes of the LGM Laurentide glaciation and local ice advances extended onto the continental shelf, but the piles of rocks left after the glacier melts—called terminal moraines if at the glacier's front and lateral if at its side—indicate that they rarely reached the open sea. Rather, they ended behind a series of elongated topographic islands produced by terminal moraine remnants deposited by older Pleistocene glaciations.[28] In many places pressure from the weight of the glaciers elevated the edge of the continental shelf above sea level. These forebulges created islands along the coast. Behind these islands the lobes of the LGM glaciers seasonally dissolved into ice shelves, meltwater pools, seawater channels, and bays. As deglaciation progressed, in a process known as transgression, rising seas swallowed up these landforms, which later became famous to fishermen as the Grand Banks, Browns Bank, and Georges Bank.

The most recent analysis places the outer boundary of the glacial front from the outer edge of the Grand Banks southward to the northern end of the Georges Bank.[29] If this reconstruction is correct, westward-bound Atlantic mariners could have made landfall on the eastern edge of the Grand Banks. This area may have been devoid of plant and animal life, but landfalls, no matter how barren the beaches on which they're made, are of particular comfort to terrestrial creatures, especially conservative scientists.[30] From there south to the Georges Bank are a series of islands, which dredging and paleoecological reconstructions suggest had a pine tundra mix of plants and mammoth fauna (figure 9.3).

In any case, the continental shelf would have been above sea level and available for plant and animal colonization from Browns Bank, which fronted an ice-covered Gulf of Maine, southward to the Straights of Florida. Throughout this distance of some 1,800 kilometers, the shelf was transformed into a wide extension of the coastal plain. Off the coast of New Jersey the shelf is about 150 kilometers wide, while at Cape Hatteras it is 23 kilometers wide. At its greatest extent it reaches more than 130 kilometers east of the coast of central Georgia. From this point southward it narrows to less than 3 kilometers, at Key West. A series of sandy ridges up to 5 meters high along the entire East Coast shelf is thought to be LGM barrier beaches or beach dunes.[31] (The subsequent sea transgression built post-LGM dunes.)[32]

Today sea currents flow over the shelf and intermix with a multitude of freshwater drainage systems, well-developed estuaries, and large bays. By contrast, during the LGM primary rivers captured the second-order drainages and flowed together after breaching the coastal plain. Above Cape Hatteras the shelf slope becomes progressively steeper, pro-

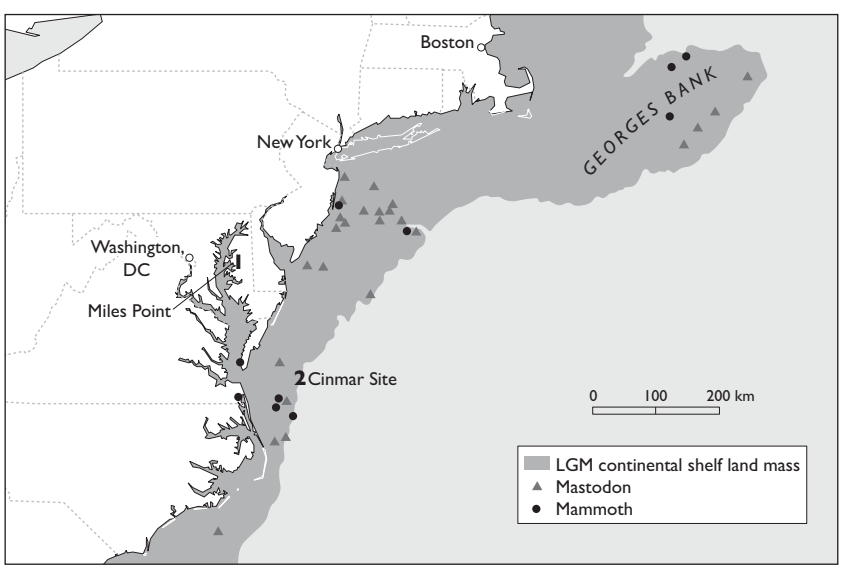

FIGURE 9.3.
North American Mid-Atlantic continental shelf at the Last Glacial Maximum, with finds of submerged late Pleistocene mastodons, mammoths, and artifact sites. (Based on Whitmore, Emery, Cooke, and Swift 1967.)

ducing increasingly higher banks extenuated by isostatic uplift above the LGM beach. The rivers that trended eastward across the outer shelf sculpted submarine canyons as they cut through the continental slope to reach sea level. These canyons would have been similar to small fjords, with relatively high banks flanking both sides of the river bottoms and extending up long, narrow inlet channels.

Although seasonally ice choked, rivers north of the Susquehanna drainage system probably abraded and carried large sediment loads of glacial debris and loess. They also transported glacial meltwater. In spite of their high sediment content, they did not develop large deltas when they emptied into the sea, because heavier matter tumbled down the precipitous continental slope. Longshore currents carried finer sediment particles northward, where they were deposited on coastal dune ridges or simply intermixed with particulate matter settling to the bottom of the sea.[33]

South of Cape Hatteras, the waters would have been saline because of low river runoff and the inflow of warmer, saltier waters brought by the Florida Current. The waters north of Cape Hatteras would have been relatively low in salinity due to river runoff and greater seasonal temperature variations. The summer offshore sea surface salinity during the LGM along the northern coast has been calculated to range between 30 and 32 parts per thousand, with sea surface temperatures of between 13°C and 16°C.[34] This is about 10°C cooler than the salty waters of the current Chesapeake Bay. We suggest that traveling upstream through the canyons, one would pass rapidly through salt regimes to tidal mixing with freshwater channels. These environments would have been reasonably produc-

tive for various shellfish, and shells are common fossils in the LGM strandline deposits of Long Island and New Jersey. Fossil walrus bones are also common in this area, and it has been suggested that Long Island was an important walrus rookery.[35]

The slope of the continental shelf ranges from 20 to 100 kilometers in width and has an average 4 degree drop in elevation. This would provide a suitable but narrow habitat of sea grasses for creatures that inhabit shallow offshore environments. Although planktonic foraminifers dominate the sediment of the entire continental slope, they increase from an average of 33 percent north of Cape Hatteras to nearly 90 percent of the carbonate sand fraction in the south.[36] These abundances imply reasonable ecological productivity, especially in the south. This productivity is further indicated by shallow-water fossils such as mussels, oysters, coralline algae, oolitic beach rock, and coral reef debris and by freshwater and saltwater peat beds in relict sediments of littoral and sublittoral environments that existed during lower sea level stands. Fossils from gray whales and walrus are commonly dredged up from the continental slope. Their present-day feeding behavior suggests that these mammals turned over the slope sediments, further enhancing the habitat's productivity.

The terrestrial environments of the continental shelf and adjacent Atlantic seaboard would have been horizontally zoned from north to south but not as well differentiated as the vegetation patterns along today's coast. During the LGM some floral groups were displaced southward as much as 600 kilometers. Conditions such as geologic substrate, amount of available water, and seasonal storm tracks would have created a variety of local ecosystems. Many of these would have had plants and animals that do not coexist today; they were unique systems without modern analogues. The net effect would have been marked species diversity, with sustainable and predictable resources throughout each major zone.[37]

To the north was a tundra environment where an open, spruce-dominated forest grew along the Laurentide Ice Sheet. This tundra snaked along the higher elevations of the Appalachian mountain chain as far south as South Carolina. The forest was identified by spruce, fir, and pine pollen peat dredged up from the northern side of Georges Bank.[38] It is highly likely that these fossils represent local growth, for there are no upwind sources for the pollen. Thus, it appears that forests grew in sheltered localities even in the extreme north, directly fronting the glacier. An LGM peat sample from the submerged coastal plain on Maryland's eastern shore was also dominated by spruce and pine pollen, although fir, oak, sedges, water lilies, ferns, and various moss species were also recorded. Other boreal trees—including fir, larch, hemlock, and birch—were much farther north than spruce. This evidence suggests that the prevailing forest ecosystem expanded to the margin of the continental shelf in various localities during the LGM.[39]

Although pine pollen is abundant over most of unglaciated eastern North America, only in the southern forests were pines the dominant trees. The LGM piney woods, along with various temperate hardwoods, extended to at least 35° north latitude. The Florida Penin-

sula had open parkland with warm-temperate species of conifers. This environment may have extended along the Gulf Coast.

Fossils are rarely preserved in eastern North America because of the acidic soils. In locations where fossils are preserved, assemblages include animals known as disharmonious faunas that don't normally live in the same environment, indicating a mix of open parklands and forest environments. In general, the fossil remains of major big game species include caribou and musk ox, which are found on the upland tundra zone. Mammoth and mastodon are found throughout most of the unglaciated regions, along with white-tailed deer, bison, and horse. There is a surprising variety of smaller mammals that no longer live side by side in today's world. The fact that some of them required open grassland and others were forest dwellers indicates that tree cover and grasslands were discontinuous and patchy, with many animals living along ecotonal boundaries. Remains of horse, bison, camel, tapir, beaver, dire wolf, and white-tailed deer dating to nearly 18,000 years BP were found in a buried pond deposit on Tilghman Island, Maryland, near the mouth of the Choptank River.[40] LGM fossils have been dredged up by various commercial endeavors working the shallow deposits on the continental shelf. Frequently the bones of mammoths, mastodons, whales, and walruses are brought into museums to be identified, whereas less dramatic, smaller specimens are usually not reported (figure 9.3).[41]

Submerged locations in northwestern Florida rivers and sinkholes have produced a wealth of extinct faunal remains, primarily mastodon, mammoth, and horse, as well as seal remains.[42] In many cases their context indicates that they were killed or scavenged by humans. Carved ivory artifacts found in these deposits have been attributed to Clovis craftspeople, but the radiocarbon dates are somewhat older than Clovis.

Shawnee Minisink, at the Delaware Water Gap in Pennsylvania, is the only other East Coast Clovis site where perishable remains were preserved. Its association of seeds of edible plants such as hackberry, blackberry, chenopod, hawthorn plum, and grapes indicates a broad range of seasonally edible resources. Unidentified fish remains corroborate this notion and show that fishing technologies were known to Clovis people.

As with the Solutrean situation, it is difficult to assess the importance of coastal and marine environments for Clovis peoples because these localities are now underwater. However, the great number of Clovis artifacts eroding out on the intertidal zone of the Chesapeake and those dredged up from the bottom of the bay indicate that major occupation sites were located at strategic spots for exploiting the bay and its estuaries.

A BIRD'S-EYE VIEW OF THE FROZEN NORTH ATLANTIC

It has been suggested that the LGM North Atlantic waters were too cold and their ecological productivity too low to sustain most animal life, let alone humans.[43] Such a blanket assessment reduces the entire North Atlantic and the entire duration of the LGM to a static event, rather than the ever-changing fluid process that it was. Although produc-

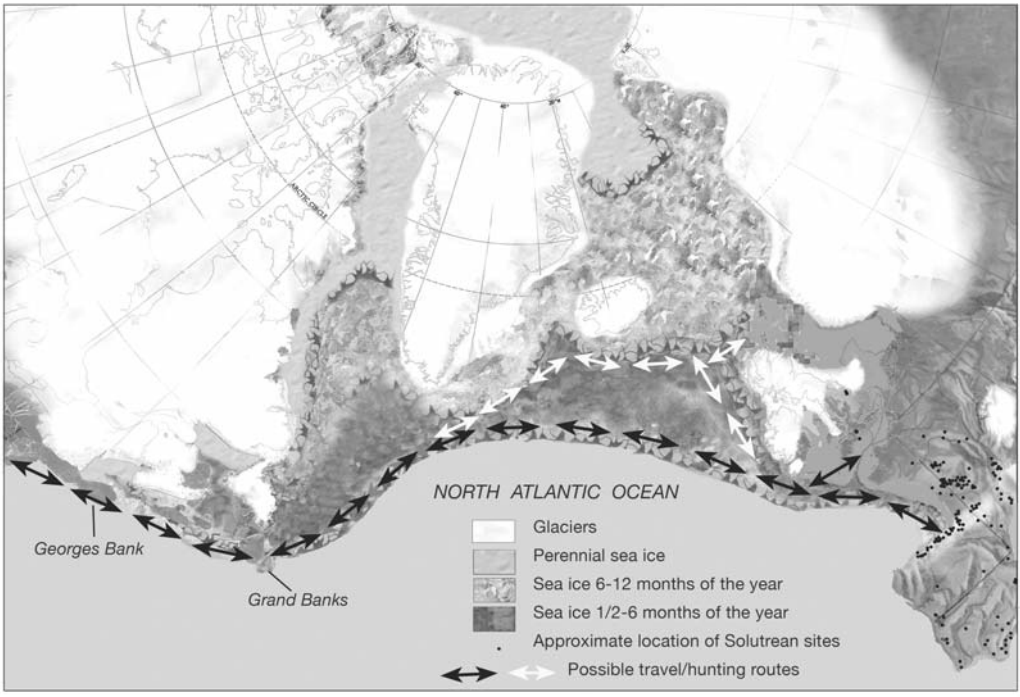

FIGURE 9.4.
Reconstruction of North Atlantic sea ice cover during the Last Glacial Maximum, with hypothesized Solutrean migration routes. (Based on de Vernal and Hillaire-Marcel 2000; Dyke and Prest 1987; Lambeck 1995; Pflaumann et al. 2003; Preece 1995; Rida and de Vernal 2008.)

tivity may have been lower in the seas underlying perennial ice cover, the effects of seasonal freeze-thaw and other natural processes would have enhanced primary biological productivity along the shifting margins of the ice pack.[44]

Marine ice exists in many forms, but those most important for this study are perennial ice, seasonal ice, icebergs, and floating ice islands. The paleoceanographers A. de Vernal and C. Hillaire-Marcel used the distributions of dinocysts to define the extent of the LGM sea ice cover.[45] Dinocysts do not dissolve as readily as the biogenic carbonates of other fossils; hence, they are relatively abundant and well preserved in the sediments of ocean environments. Some dinocysts are found exclusively in ice-free environments, whereas others predominate in regions with more or less extensive sea ice cover (figure 9.4).[46]

As the name implies, the perennial ice pack is always present in the Arctic Ocean, but its extent varies with thermal trends. We are now in a warming stage, and the margins of the pack ice are retreating northward at an alarming rate. During the LGM, when the glacial ice sheets were near their maximum, permanent sea ice formed along the western Atlantic coast as far south as roughly 50° north latitude, or present-day Newfoundland. Sea ice was also periodically distributed around the eastern margin of the North Atlantic, perhaps as far south as the British Isles. Deep-sea cores show that the biological pro-

ductivity beneath the perennial LGM ice was low, perhaps as much as 50 percent less than today, and life ecozones were shifted southward from their present locations to compensate for these harsher physical conditions. This low productivity nevertheless would have provided enough resources for the Paleolithic people who made their living from the sea.[47]

The margins of the perennial sea ice extend when the adjacent water freezes during colder months and shrink by thawing and breakup during warmer months. The ice produced in this manner is called ice of the year or seasonal or annual ice. Seasonal ice can also form on or be blown by storms onto beaches, where it becomes landfast ice. These processes vary, producing annual ice cover that lasts from a year or more to a few weeks or less, depending on short-term weather fluctuations such as a colder than normal year.

The extent and location of the ice edge is important, because the adjacent surface waters are richer in major nutrients, with algae and plankton particularly abundant.[48] The outer margins of the annual ice and landfast ice are relatively fluid, with open-water channels called leads forming and closing. Open leads create microhabitats for various kinds of marine mammals, other sea life, and waterfowl. Polynyas, small ponds of open water formed in the polar oceans and on land-fast ice, provide the habitats relied on by overwintering marine birds and mammals.[49]

De Vernal and Hillaire-Marcel suggest that the LGM had large seasonal contrasts in temperature, with very cold winters but relatively warm summers. If the LGM annual ice behaved like its modern equivalent, when temperatures turned warmer it would have begun to melt and crack, forming leads. These channels could close with a change of wind or continue to widen, but eventually the ice would break up into myriad ice islands, both big and small. The islands would float with the current along with the icebergs until they melted in the summer sun. Onshore winds would have driven ice islands onto beaches, where they remained until melted unless freed by tides. Ice islands adjacent to the perennial ice edge would have been reincorporated into the ice mass as temperatures cooled in the fall.

Annual ice does not form along the coastlines of northwestern Europe today, primarily because the North Atlantic Drift raises the sea surface temperature enough to inhibit its development. During colder episodes of the LGM, however, annual ice formed along the coastline of western Europe. Landfast ice may have been common along the Aquitaine and Cantabrian coasts for several months during winters of the peak cold periods and offshore ice even more common.

During the coldest periods of the LGM, the polar front, the boundary between the cold waters of the North Atlantic and the warmer waters of the Gulf Stream, is estimated to have been at around 40°N, falling along the coastlines of Portugal and northern New England.[50] The Gulf Stream arched eastward from Cape Hatteras and flowed across the Atlantic toward Iceland, then branched southward to skim along the west coast of Europe and northwest coast of Africa before returning to the Caribbean (figure 9.1).[51]

Along its northern margin the Gulf Stream clashed with the colder waters of the

Labrador Current, bearing icebergs and ice islands on their way south. The icebergs melted faster on mixing with warmer waters, compromising the warmth of the Gulf Stream to a certain degree and releasing tons of debris; in return, the cold northern waters warmed slightly as they intermingled with the Gulf Stream. In the northeastern ocean the currents turned north again and headed in a large counterclockwise gyre along the coast of northwestern Europe, on to Greenland, and eventually back to Labrador to begin the cycle anew.

These circumstances produced three parallel zones of surface water types, based on temperature: polar waters, subarctic waters, and warmer Atlantic waters. Their boundaries shifted north or south depending on a variety of climatic and oceanographic phenomena, including short and longer-term thermal cycles. Hence the sea surface temperature of a local water, such as a part of the Bay of Biscay, may have stayed relatively static during one person's lifetime but shifted so rapidly during another period that people were cognizant of the changes.

Since it is difficult to recognize these important but subtle changes at the scale of analysis afforded by deep-sea cores, average temperature calculations are only suggestive. That said, the average LGM temperatures of offshore Cantabrian waters at 40°N are estimated to have been between 1.5°C in February and 9.5°C in August, with October and November temperatures reaching as high as 7.0°C.[52] At 50°N these temperatures would have been on average about 2°C–12°C colder.[53] Atlantic cod can tolerate temperatures from -5°C to 20°C and prefer those ranging between 0°C and 11°C.[54] The shallowly submerged Flemish Platform east of the Grand Banks is thought to have been a major cod breeding ground during the LGM.[55] Thus, even though the LGM Cantabrian waters were colder than they are today, they were still habitable by cod, an important subsistence resource for humans and other marine predators.

The continental glaciers discharged massive quantities of icebergs into the North Atlantic at least six times during the LGM. Although the cause of these Heinrich events is unclear, they were probably provoked by internal ice sheet failure or rapid expansion in response to global cooling. Whatever their origin, these events were characterized by a rapid cooling of seawater surface temperatures, decrease in ocean salinity, and marked increase in the percentage of the foraminifer *Neogloboquadrina pachyderma,* which prefers waters colder than 10°C, in deep-sea cores. Rises in sea surface temperatures immediately after peaks in ice-rafted debris appearance are implied by a decrease of *N. pachyderma* and an increase of other species such as *Globigerina bulloides*. Would prehistoric seamen have ventured out on the Atlantic during a Heinrich event, or during the subsequent warming phase? Perhaps because we are landlubbers, we suggest that people began to exploit the sea during the warmer phases, but they might not have waited that long.

During Heinrich events huge amounts of ice eventually ended up on the southern edge of the polar gyre (figure 9.1). At that latitude, warmer waters from the south accelerated the melting of the ice, leading to a rapid deposition of carbonate-rich IRD in a wide belt across the ocean.[56]

The influence of icebergs on phytoplankton production in surface waters is controversial. Some authors suggest that the high diversity and relatively low numbers of benthic foraminifers indicate a low flux of food. Thus, productivity would have decreased during IRD events.[57] Others view the lower abundance of these fossils as a preservation artifact and suggest that nutrients released from the melting icebergs created a special environment in the surface waters that was highly productive.[58]

Atmospheric and ocean circulation strengthened during the full glacial period. This led to an intensification of upwelling and consequent increase in biological productivity. The diatom and organic carbon content of the LGM section of a core taken off the coast of Portugal indicates that the summer northerly trade winds created such an upwelling of nutrient-enriched waters there.[59] Further, the mixing of the Gulf Stream's warmer waters and the nutrient-rich cold waters would have encouraged the growth of phytoplankton, which in turn would have sustained shoals of fish, sea mammals, and waterfowl.

The prevailing Canary current would have carried nutrient-enriched waters directly into the Bay of Biscay and intersected with the southern margin of the annual ice. Hence it is highly likely that ice edge–adapted animals would have been common along the ice age coastline of northern Spain and northward. In fact, during various phases of the LGM this region was probably an excellent location for rookeries used by seals and perhaps walruses. Today seals and other marine animals overwinter on pack ice and follow the receding ice into the Arctic waters of the North Atlantic in the summer. These creatures' ancestors no doubt behaved similarly throughout the LGM and the waning years of the Late Pleistocene, overwintering near the northern Spanish coast and providing ample time for astute and inventive hunters to learn to harvest their rich bounty. These beasts were not only obvious and important sources of the meat, blubber, and blood necessary for withstanding extreme cold environments but also excellent sources of hides, sinew, and gut, the last extremely important for making waterproof clothing. Seals are also an excellent source of oil, which would have been an extremely important resource in the wood-impoverished environment of LGM Spain.

Common and king eiders and other avian species that overwinter on ice edges, leads, and ponds are important sources of food and down for the Inuit today and would have been available as winter resources for Solutrean hunters. The great auk and other members of its family, as depicted by Solutrean artists in Cosquer Cave, would have been common inhabitants of northwestern European waters.[60] These now extinct birds were about the size of a goose and unable to fly. Prized for their feathers, oil, and meat, they were easy prey and could be simply grabbed by hand. Like the other beasts of subarctic waters, the great auk migrated with the ice edge, northward from the Bay of Biscay in the spring and southward in the fall. This behavior pattern is likely to have been ancient, and pre-maritime hunters probably grieved when the last great auk swam away each spring.[61]

Much progress has been made in assessing the paleobiodiversity of the earth's oceans, but the exact processes and interactions involved in creating that diversity are still under debate. It is axiomatic, however, that although the diversity of life-forms decreases from

low to high latitudes, the population density of those that survive increases, even in the coldest polar waters. Deep-sea cores show that the density of foraminifera under perennial ice was low, but they were present and, considering sample size and preservation problems, are probably grossly underrepresented. Thus, no matter what the productivity of the LGM North Atlantic ice edge was, the ancestors of the species now present, even if in greatly reduced numbers, would have been sufficient to sustain the impact of predation by Paleolithic hunters.

The assumption that the LGM ocean was too cold to support life is an oversimplification of the complex paleo-oceanographic processes that took place then. It is our contention that during certain times and at certain latitudes, the LGM North Atlantic not only was capable of sustaining higher forms of life but was a comparatively rich environment that was used, explored, and understood by peoples whose ancestors had faced the ocean for centuries.

10

LIVING ON THE ICE EDGE

Ethnographic Analogies

> It is a reasonable assumption that Atlantic sailors throughout the ages have well understood the regularity of tidal flows and the direction of the prevailing winds, and would have been able to judge the weather patterns with tolerable accuracy before embarking upon a journey.
>
> BARRY CUNLIFFE, *FACING THE OCEAN: THE ATLANTIC AND ITS PEOPLES*

For most modern people life on the edge of the sea ice is as alien as life on Mars, and ignorance of this frozen world prompts many misconceptions and fears. After we make presentations on this topic we are asked the same questions: Wasn't it dangerous? How could people survive on the ice, especially primitive cavemen? How could they keep warm? What did they use for fuel? What would have been available for food, and how did they find water? Since there is no way to know how Paleolithic people adapted to this environment, we address these and other questions by illustrating key techniques used by the Inuit people of the American Arctic for hunting and surviving on the ice edge. Although the Inuit ancestors no doubt took a long time to perfect their adaptations, these techniques evolved from common sense and an acute knowledge of their environment. Here we invoke a convergence of lifeway strategies, as Inuit and Paleolithic peoples faced similar environmental issues, and we base much of the following narrative on the ways that the former have exploited the ice edge.[1]

To understand Solutrean lifeways we must consider reconstructions of ice age environments and model the entire ecosystem rather than just the uplands that are currently above sea level. Even though we do not have complete evidence of the ancient natural conditions, we can make assumptions based on our knowledge of the dynamics of subarctic marine and coastal environments, especially as to animal behavior and the seasonal influences of winds, currents, and tides. With this ecological information and comparisons to historic and more recent human adaptations to analogous environments, we can better understand this unknown portion of ice age human life.

Ignoring the fact that the Last Glacial Maximum continental shelves and coastal and oceanic resources were available for people to exploit simply because these areas now rest beneath the sea is a major mistake in reconstructing Solutrean, and possibly pre-Clovis, life. The simple proclamation that the marine environment was too harsh for Paleolithic people to exploit only compounds the error. During the thousands of years that the Solutrean people of northern Spain eked out a living from the narrow strip of land wedged between the ice age sea and ice- and snow-covered mountains, they no doubt observed and learned the many moods of their natural world. The resources of the sea and continental shelf likewise would not have escaped their attention. These early innovators would have tested and pushed their understanding of the ice edge and the sea until they could best take advantage of these environments.

ADAPTING TO LIFE ON THE BEACH: A PRELUDE TO THE DISCOVERY OF AMERICA

Reconstructions of the LGM marine environment of the Bay of Biscay are dependent on the polar front's changing latitude, caused by the many shifts in global cooling and warming. During colder phases the polar front extended southward into the bay or perhaps even farther, into the lower latitudes along the west coast of Portugal. During warmer phases it receded north.[2] In Solutrean times these shifts occurred in various degrees many times. We are witnessing the same process today as global warming shifts the polar front northward.

The Gulf Stream, then as now, was warmed in the southern latitudes, flowed northward along the East Coast of North America, where it picked up trees and other flotsam flushed out to sea, and merged with the iceberg-laden Labrador Current off Cape Hatteras to become the eastward-arching North Atlantic Drift (figure 9.1). The North Atlantic Drift diverged into two branches, one passing south of Iceland and the other curving southeast toward the Bay of Biscay, where ice pushed southward by surface currents along the Celtic-Armorican-Aquitaine coastline further cooled the waters. In contrast to today's notably ferocious seas, caused by winds driving water across the shallow continental shelf, the deepwater reach of LGM coastal waters would not have been so turbulent. To the west the Canary Current slid past Portugal and then western Africa before making its final leg back to the Caribbean, completing the North Atlantic Gyre.

The Subarctic Gyre and the North Atlantic Subtropical Gyre are important oceanographic aspects of our studies not only for understanding how these currents affected ice floes and navigation but also because, as mentioned above, terrestrial debris flushed into the oceans is caught up in gyres and eventually washes ashore in distant lands.[3] Icebergs, trees, and flotsam carried from North America were scattered along the outer continental coastlines of western Europe, where they collected on catcher beaches and in estuaries. During the LGM these resources, especially the wood, would have been highly prized by the human inhabitants of the western European tundra for tool manufacture and lodge

construction and as fuel. Perhaps, as in medieval Iceland, these resources were so dear that driftwood cast up on specific beaches was considered the property of designated families.[4] Woe to anyone who took wood off the wrong beach! Tree trunks and branches from North America that washed ashore along with the annual migrations of birds and sea mammals would have been clues that there were forests and lands beyond the horizon.

Winds from polar high-pressure systems that formed over the glaciated areas of western Europe would have drained into subtropical lows, creating unsettled weather patterns. During warmer seasons the more marked temperature gradient between air from the ice fields and air from over the warmer seawater would have tended to produce more offshore surface winds as they collided.[5]

The movement of ice is a constant battle between wind and sea currents.[6] Most of a berg is below the waterline, where currents sculpt it into a keel. Bergs' skyward surfaces resist the wind and act as sails. On calm days they drift along with the current, but strong winds can direct their movement. As with a sailboat, if the wind blows with the sea current, the ice moves rapidly; if the breezes and currents balance, the ice does not move. Westerly winds would have generally pushed ice floes north and east, where they would have piled up on the Celtic and Aquitaine coasts and built westward along the Cantabrian coast. But a strong east or south wind would have sent the ice moving back out to sea.

During colder LGM phases the pack ice was likely still out at sea in the early fall, but currents and increasing onshore storms eventually would have brought it, with the help of high tides, onto the beach, where it would have been grounded until spring. Winds that blew parallel to the shore would have carried the ice pack along it, while onshore winds would have held the ice fast to the shore and might have caused it to crush and pile. Offshore winds would have split open-water channels or leads parallel to the coast into the ice pack and shifted it seaward.

The leads could have been several yards to several miles wide and opened only briefly or up to weeks at a time. After a lead opened, new, salty ice would form an apron that built outward from its margins toward the center until the entire lead was covered. Ice aprons are thickest near the lead edge and gradually thin outward. Transitions between weak and safe ice can be observed as distinct color changes that represent different stages of ice development. When an ice apron grew thick enough to support a person it could have served as a smooth avenue for foot travel.

By winter, when the ice was thick enough that it did not break, its topography and movement would have been of concern to a hunter. In some areas winter ice might break into huge chunks piled high along pressure ridges, sometimes miles-long cracks in the ice caused by heating and cooling. In other areas older ice went through several seasons of warming that sculpted it into gently undulating surfaces and vast, flat expanses that remained unbroken all winter. Salts dissolve out of polar ice during summer thaws, so when melted this older ice would have provided freshwater for drinking and cooking.

By late spring the floes would have broken apart, creating ice islands of varying size. Large islands moved with the current, while smaller islands (called pans) were pushed

by the wind. If there was no wind the ice moved together, but if a wind was contrary to the sea current the ice sizes would intermix. Some islands were so large that their movement was imperceptible, and hunters would have to be extra vigilant or face the possibility of being set adrift on an ice raft. An experienced hunter would keep an eye on the current by throwing chunks of ice in the water, watching their direction and speed of drift. If the chunks floated away, the island was likely stable, but if they stayed alongside, the island was likely moving with the current.

There are many Inuit stories of hunters who were trapped on the ocean ice and unable to reach land. Some survived for months; others were not so fortunate and drifted away, never to be heard from again. An elderly friend of Dennis's at Point Barrow was quick to point out, however, that no one from the town had been lost on the ice for several years because GPS handheld receivers and cell phones are now part of standard hunting equipment. When well-equipped New Age hunters become stranded they simply call home, and someone, perhaps in a helicopter, comes to the rescue. These new technologies conveniently come at a time when global warming has made pack ice unpredictable and dangerous. Traditional hunters now run a higher risk of being trapped on ice, and without these satellite technologies many would be cast away on the open sea. Similarly, the LGM's shifting climates and ice conditions required new technologies for survival, but many people were likely lost to the ice or sea while they were being developed. Perhaps the skin boat is analogous to the helicopter.

Weather was another thing that was necessary to keep track of. Early hunting cultures learned commonsense ways to predict the weather on the basis of various atmospheric conditions and no doubt keenly observed important indicators of change—changing wind directions and intensity, for example, or the twinkling of stars before a powerful storm. Light rings around the sun or moon indicate approaching wet weather. Haze, fog, and clouds frequently precede storms and indicate the direction from which the storm will emerge. Elongated clouds stretching out at right angles to the wind indicate an advancing storm front. Abnormal rising or falling of the tide or increased surf warns of an approaching windstorm. Weather predictions can also be made on the basis of animal behavior. For instance, wolves howl when the atmospheric pressure rises; seals basking for long periods indicates good weather. On the other hand, if seals rise only briefly to the sea surface and then disappear, there might be an approaching storm.

If a storm approached while a hunter was in a boat along the ice edge, he could make a quick retreat into a lead to find calmer waters. A light, flexible skin boat could have been pulled onto the ice and turned on its side, perhaps near a pressure ridge that blocked the wind, to provide a quick shelter. If it appeared that the weather was going to set in for a long spell, the hunter might have used a sail or skin tarp to expand the shelter and snow blocks for additional protection.

Oil or blubber would have been used for heating, cooking, and light. All that was needed was a shallow container or lamp to hold the fuel. The container could have been as simple as a depression chipped into the ice or, on land, dug into the ground. A skin could be

WE'VE BEEN TO NEW YORK!

In the summer of 1968, while I was directing an excavation near Point Barrow, Alaska, an Iñupiat hunter told me that a couple of men from his village wanted to speak with me. Several weeks later two fellows showed up at the site. They approached me and without any introduction announced, "We've been to New York." A bit nonplussed, I responded, "That's nice. What were you doing in New York?" The answer was, "Coast Guard took us." Confused, I asked how this had happened. The answer was, "Icelandic Navy gave us to the U.S. Coast Guard." This was the start of an intriguing hour-long conversation in which they recounted that they had been spring hunting on the edge of the ice when the ice broke up and set them adrift. They survived by hunting seals while their ice island traversed the polar sea, skirted the North Pole, and entered the Denmark Strait along the east coast of Greenland. As they drifted south, the floe had begun to shrink rapidly and they had gotten "a bit nervous." Fortunately they were sighted and picked up by the Icelandic Coast Guard, who transferred them to the U.S. Coast Guard. They spent a few days in New York, where they saw many wondrous sites before they were returned to Point Barrow.

From our point of view, they had survived an extraordinary hardship on an ice floe for several months with only the equipment they had brought hunting. However, by the time they told me their story, the rigors of the ordeal had come to seem relatively insignificant compared to having been to New York!

A few years ago I was back in Point Barrow. Now that we were developing our Solutrean hypothesis, I wanted to get more details of how they had survived on the ice. A friend at an elder care home remembered the hunters and their adventure, but he had few details, and the castaways had long since passed away. *Dennis*

placed in the depression to form a bowl, keeping porous ground from absorbing the oil. A wick could have been made from fine wood shavings, moss, or even shreds of the skin, and moving more of it into the fuel would decrease the intensity of the flame. Hanging a slab of fat over the flame in such a lamp can keep it burning unattended for many hours: when the oil in the container becomes low, the exposed wick burns higher and melts more oil from the fat above.[7]

Seals and great auks would have produced many pounds of fat or blubber. The oil could be rendered by placing strips of blubber in a container or on a non-porous skin and allowing the oil to ooze out naturally. This process goes faster on warm, sunny days. If oil was needed more quickly the blubber could be placed near a fire and squeezed out by hand. Moreover, blubber strips would burn like logs if placed in a fire.

Along with their use as fuel, animal fats would have been excellent for waterproofing many objects, in particular clothing and skin boat coverings. Seal oil can keep a boat made

of bearded sealskin waterproof for several weeks, but eventually the boat will need to be hauled out, dried, and re-oiled. Celtic mariners used boats known as currachs, made of cow skins stretched over wooden frames, for unknown millennia. Currachs remained seaworthy for several months when treated with sheep tallow.[8] Bovid hides were available to Solutrean people, along with excellent sources of waterproofing oil.

Though the ice pack would have been a world of frozen water, freshwater could be had by applying heat and was even found seasonally in meltwater ponds. Freshwater can be melted from snow piled around a depression and collected from troughs chipped in the ice near a fire. These troughs are also handy sources of water while cooking. Brave souls can melt snow with their body heat by placing it in a pouch next to their skin.

During a storm the locations of leads can change, as old ones close and new ones form elsewhere. Finding a new lead or the ice edge is relatively easy, for the difference in temperature between the warmer seawater and the ice causes a thick fog bank, which can be seen for miles, to hang over the open water. Moreover, on overcast days sea ice reflects against the clouds as dull white, while dark streaks indicate an open lead below, and snow-covered land reflects as brilliant white. If newly fallen snow covers the aprons in the leads, they reflect as unusually bright pathways in the clouds.

Traveling on and around sea ice and open water would have been relatively simple, especially on clear days. Beyond celestial positioning, mariners could navigate by the Picos de Europa, which loom 2,500 meters above the southern horizon, providing a constant landward marker. Given the earth's curvature, the mountains could be seen from 50 kilometers or so out on the ice or sea. Fixes on distinct landmarks such as this would have provided destination directions. When landmarks shifted position on the horizon, it was a warning that the ice was beginning to move.

When landfast ice formed during the winter, it greatly expanded the available geography for pedestrian hunting. In fact, there would have been little difference between hunting on snow-covered ground and on landfast winter ice, and the latter's return of seal meat, fuel oil, and other animal products would likely have been much greater, as land mammals grow leaner throughout the winter.

HUNTING THE ICE EDGE

One of the greatest impacts of the LGM was the forcing of life zones southward by hundreds of kilometers and the reorganization of those zones into disharmonious biospheres. Species that now flourish in northern waters would have found themselves displaced by the expansion of the polar ice cap and the formation of the annual pack ice, to such glacial refugia as the Celtic-Armorican-Aquitaine coastlines and the north coast of the Iberian Peninsula.[9]

Other than harbor seals, the seals of the North Atlantic are generally associated with ice-edge environments for breeding and birthing during late winter and into spring. When

the ice breaks up in the late spring, the seals stay with the edge or with floating islands as the ice retreats northward, and they return as the ice builds southward in the fall.

Since seal pups are weaned within a few weeks and are not particularly weather dependent for growth, we suspect that the LGM's southward shift of rookeries did not affect the birthing season to any great degree and that seasons of birthing, breeding, and molting—the periods when seals are the most congregated and most vulnerable to predation—have not changed significantly through time.

Seals can have a dozen or more breathing holes, and they start making them when the ice begins forming in the fall so they can break through with their heads. As the ice thickens they keep the holes open by gnawing and scratching. Holes can be identified by an elevated circular platform caused by water pouring over the ice and freezing when the seal surfaces. Passing seals use any breathing hole they encounter, so hunters can return after a kill and hunt again. A patient hunter with a pike or a self-barbed spear could get several in a day from a single hole. Hunters in groups might tend holes scattered across the ice to increase their chances of getting seals. Consequently, during the winter when the ice was solid, whole extended families might have moved offshore for prolonged periods to collect a supply of food and oil.

During the winter adult female seals tend to stay beneath the ice or inside the dens in heavy ice beyond the leads. Dens can hold several seals and their pups but would have been hard to find. So despite the bounty dens held, major winter hunting activities probably centered on breathing holes for seals and leads and open-water areas for overwintering birds.

When the sea ice began to fragment and open in late spring, seals would have appeared in greater numbers. Throughout the spring and summer they sleep on the ice and bask in the sunshine. During these seasons onshore winds push unconsolidated floes toward shore, and many hundreds of basking seals can be seen scattered across the horizon. Scenes such as this would have tempted any hunter to consider ways to get out among the pans and may well have initiated experimentation in the use of watercraft to harvest nature's ice garden.

The principle seal-hunting methods among Arctic peoples are clubbing, netting, spearing with a barbed pike, and harpooning, alone or in combination. The choice of method varies with the species of seal, the prevailing geographic and climatic conditions, and the season. Clubbing is confined to gregarious species, such as the gray seal, which unlike the harp or spotted varieties sometimes establishes rookeries on the beach well above sea level. Ringed seals can be clubbed on the ice if a series of holes are plugged and the seals are forced to come to a central hole for breathing. When a hapless creature appears, it is clubbed to death and dragged out of the water.

For the Solutreans, hunting seals in leads or while they floated on pans along the ice margin would have required either darts propelled by a spear thrower or bows and arrows. Parts of spear throwers have been found in Solutrean middens, but we are less confident that they had bows and arrows in the areas around the Bay of Biscay. A spear thrower

could be used effectively by a hunter either standing on the ice or seated in a watercraft. Retrieving dead seals would have been possible for pedestrian hunters without special equipment if the animals snagged on the ice edge while floating in the current of the salty water. If the apron was too weak to walk on, the carcass could be retrieved with a pike or a hook, which might have been as simple as a branch tied to a line.

Other trapping techniques include the use of nets made of hair, which are stretched across narrow channel inlets to catch seals coming and going. At least one of the pennipeds painted on the walls of Cosquer Cave is covered by a series of lines that could represent netting (figure 5.11g). Other seals are depicted with lines that probably represent spears penetrating their bodies.

Although one could set a net by wading in the water, this would be most easily accomplished from a boat. Other than the possible illustration of a seal caught in a net at Cosquer Cave, there is no evidence of Solutreans using nets for hunting seals. There is also no direct evidence of the terrestrial hunting technologies proposed by Lawrence Straus (see chapter 8).[10] Each is equally plausible.

Ice hunting can be extremely hazardous, especially near breakup, for a sudden change of wind can drive an ice floe away from shore. If hunters found themselves in this situation without boats, they would be marooned and adrift until blown back into the ice pack or onto shore. They could survive long periods of floating in the northern currents with all-weather gear and clothing. (Solutrean people clearly knew and used winter technologies, or they could not have survived the LGM even if protected by caves.) If the ice melted out from under them, however, they would perish.

There were more marine resources available for Solutrean people than just seals. Saltwater fish such as halibut and flounder joined salmon and trout as decorations on cave walls, no doubt speaking to their importance.[11] Walruses may have been common on the ice, and many overwintering migratory waterfowl would have frequented leads and open-water ponds. The great auk was no doubt a major resource for people who lived along the beach.

Adding seals and auks to their subsistence strategy would have been a significant step for ice age people. These animals provided not only oil and fat for fuel but also nutrients and calories critical for surviving the winter and spring months. This motivation probably accelerated the understanding of animal behavior and ice floe dynamics, leading to innovations in ice edge hunting. Simply extending winter activities onto the landfast ice would also have had big rewards.

By summer the ice was clear of the bay and people shifted their activities to hunting terrestrial animals, fishing, and logistical tasks such as collecting stone for artifact manufacture. Summer and fall camps were likely established in the foothills for hunting ibex and other subalpine species and for spearing spawning fish. This also would have been the time of year when plant resources were harvested, some with special significance for healing various ailments. The summer and fall camps were normally abandoned in the late fall as attention once again turned toward the frozen sea. As discussed in chapter 9 the polar front shifted its position many times during the LGM, and during warming cli-

matic episodes the winter and spring habitats of seals shifted northward along with it. It is highly likely that humans adapted to these shifts by either following the ice front's northward retreat along the edge of the continental shelf or enhancing their maritime capabilities to follow the seals across open water.

VOYAGERS

Critics of the hypothesis that Solutrean people crossed the North Atlantic are more than content to point out that there is no evidence that they had watercraft or ever used marine resources beyond those gathered from local estuaries and shores. While this is not entirely true, the evidence is indeed slim—environmental processes, such as rising sea levels, have destroyed evidence of advances in marine technology—but when placed into a global perspective it forces us to reconsider the negative position. The question of when humans first used watercraft for transportation has vexed archaeologists for decades. Constructed rafts and boats have long been considered relatively recent additions to cultural inventories, but this assumption is rapidly falling away in the face of both direct and indirect worldwide evidence of the extreme antiquity of watercraft and ocean travel. Solutrean people were likely in sync with the rest of the Paleolithic world, so it is likely that they knew of and used watercraft for transportation and to exploit the LGM marine environment.

In extreme southeast Asia, perhaps earlier than 60,000 years ago, the first mariners left terra firma for lands beyond their home shores. The events leading up to these first expeditions are virtually unknown, but the scatter of archaeological evidence on far-flung South Pacific islands leaves little doubt that they occurred.[12] The world these early explorers left behind, called Sunda by prehistorians, was created when falling sea levels exposed the continental shelf, connecting the islands of Indonesia north of the Timor Sea to the continental mass of southeast Asia.

A myriad of inter-visible islands and the human sense of adventure likely lured these first sailors away from the shores of Sunda. By 50,000 years ago voyages across the Timor Trench landed settlers on another ice age continent, known as Sahul. Sahul stretched from New Guinea southward to encompass Australia and Tasmania. So many were the successive sea voyages that by 30,000 years ago pioneers were scattered over virtually the entire expanse of Sahul and the islands of Near Oceania from New Britain to New Ireland. By 29,000 years ago the people living on Buka Island in the northern Solomons were descendants of mariners who had made extended ocean voyages of nearly 200 kilometers, more than half of which would have been out of sight of land.

Evidence of the use of watercraft in the East China Sea appears on the eastern shore of Honshu more than 30,000 years ago. Seamen buried their kinsmen in caves on Okinawa and other islands that were separated from the mainland by as much as 150 kilometers of water. Paleolithic Honshu sailors also navigated a 50-kilometer-wide channel to Kozushima in the Izu Island chain, where they found obsidian, volcanic glass that they carried back to the mainland to make into weapon tips and knives.[13]

Whether the idea of boats and the skills necessary for water travel developed in multiple independent centers or at a single center from which it spread across the world is a thought-provoking question for future research. At about the same time period when early mariners were exploring the south Pacific, evidence of water transportation appears in other widely separated regions. For example, a date of 51,000±12,000 years ago derived from calcareous breccia adhering to *Homo sapiens sapiens* remains suggests the possibility of an early human occupation on the island of Crete. Since Crete was not connected to the mainland at the time of the burial, anyone who came to the island would have to have made an open sea crossing.[14] Intriguing too are Aurignacian artifacts found at Fontana Nuova di Ragusa, a site on Sicily, an island that was never connected to the European mainland. These discoveries provide intriguing indirect evidence that prehistoric humans used watercraft to explore the Mediterranean as far back as 38,000 years ago.

Most illuminating for our hypothesis of a Solutrean maritime tradition are depictions of flightless great auks, deep-sea fish, and seals found on the walls of El Pendo Cave on the coast of northern Spain and Cosquer Cave on the Mediterranean coast of France. At Cosquer a diorama of three auks is dated within the Solutrean era, to between 18,000 and 19,000 years ago, by charcoal fragments found in the vicinity of the painting. Two of the birds are facing each other with outspread wings, while a third, set slightly apart, is lying down with its wings folded. Francesco d'Errico, an archaeologist at the Centre National de la Recherche Scientifique whose research interests are Paleolithic art and technology and the evolution of human cognitive abilities, interprets this life scene as two males fighting to mate with a female, who is inviting copulation by her prone breeding posture.[15]

All recorded auk breeding sites were located on small, isolated islands with flat, easy access to breeding sites. It has been suggested that auks nested at mainland rookeries before human hunting pressure drove them onto islands.[16] However, even in regions of Greenland where the birds were not subjected to human hunting, their rookeries were on islands. It is probable that this nesting behavior evolved as protection against terrestrial predation, especially considering how vulnerable the birds were when out of water, but the trait was likely in place eons before humans were part of the predator guild. The Paleolithic artist who depicted this scene of mating behavior likely observed a battle on an island between giant males. As d'Errico points out, battles such as this must have been impressive because of the size of the birds and the fierceness of the combat, which sparked the prehistoric artist to commemorate this scene.

Solutrean artists illustrated deep-sea fish species such as flounder and halibut at Cosquer, and a lifelike tuna appears at El Pendo. Perhaps these fish were caught by hook and line from the shore, but that seems highly unlikely to us. We suggest that the fish and auks illustrated in the Solutrean rock art indicate that watercraft were used for transportation, hunting, and fishing. It is unfortunate that Paleolithic artists did not depict domestic scenes, because there are no clear images of boats. However, there are also no images of tents or other forms of constructed shelters, which they must have had to survive in open ice age environments.

The sudden appearance of Solutrean technology in Europe may also suggest the use of watercraft. Where did these people come from in the first place? Marcel Otte, a European Paleolithic specialist, argues that Solutrean technology developed from the bifacial Aturian technology of northwestern Africa and spread into Europe by crossing the Mediterranean at the Straight of Gibraltar, or perhaps farther to the east where currents are less swift.[17] Although this was not a great span to traverse, such a trip would have required watercraft. The use of watercraft by the colonizers of the Mediterranean coast of Spain and France would explain the knowledge of the breeding behavior of auks, illustrated on the walls of Cosquer Cave.

Although slightly later in time than the Solutrean, the continued use of watercraft by Paleolithic Mediterraneans is documented in southwest Greece. Here, some 13,000 years ago, long after Pacific sailors had started importing obsidian to Honshu, flintknappers from Franchthi Cave on the southwestern coast of Greece crossed 24 kilometers of open water to collect prized volcanic glass from the island of Milos.[18]

Other discoveries in the Mediterranean point to the early maritime exploration and occupation of the island of Cyprus. Here, researchers have excavated a massive pygmy hippopotamus bone bed dating to more than 11,000 years old at the Akrotiri Aetokremnos. Controversy raged when the investigators suggested that these animals had been hunted to extinction—not because this meant that people had been on the island, presumably arriving by boat, but because they had hunted the hippos to extinction.[19]

Regardless of the outcome of the debate over the Aetokremnos evidence, it is clear that early pre-Neolithic peoples settled on Cyprus and other Mediterranean islands more than 9,000 years ago. Several sites even show that these people not only got to the islands but did so in veritable Noah's arks with cattle, sheep, goats, and pigs on board. The vessels used to transport these livestock were certainly not simple skin boats or even dugouts propelled by rowers. Indeed, these mariners were likely under sail in relatively large crafts, be they rafts or keeled boats.

Such cargo capacities and sailing feats remind us of the pre-Columbian Ecuadorian balsa rafts that plied the Pacific coastline of Latin America to trade in far-flung ports. These large rafts were equipped with one or more masts and propelled by triangular fore-and-aft-rigged cotton sails. Planks inserted below the waterline through gaps between the logs of the rafts formed vanes that with adjustments in the sailing balance allowed adequate steering. According to Smith and Haslett these rafts could sail within 60 degrees of the wind.[20] By comparison, modern sailboats rarely sail more than 45 degrees into the wind. Bartolomé Ruiz, a Spanish engineer, encountered one of these balsa rafts off the coast of northern Ecuador in 1526 and estimated that it was carrying more than twenty-five tons of cargo along with a crew of twenty people.[21] In our opinion the pre-Neolithic settlers of Crete would have required a similar craft to transport their livestock to the island.

There is no question that watercraft-manufacturing technologies were developed during the Paleolithic, but the earliest physical remains of a boat are from a log craft found

in Pesse in the Netherlands that is between 9,510 and 10,040 years old.[22] A 7,800-year-old dugout canoe was excavated at La Marmotta, a wet site northwest of Rome.[23] The vessel was made from a single oak trunk and measures 35 feet in length and 3.5 feet across the stern. Three trapezoidal blocks of wood drilled with holes are thought to be fastenings for sails, while fabric fragments found in the bottom of the vessel have been identified as sail remnants. Clay models representing the same style of boat were also unearthed at the site. If these interpretations are correct, this boat is 3,000 years older than the Egyptian vessels that are known to have sailed in the Mediterranean by 3,500 B.C.[24]

Along with pottery similar to ceramics from Thessaly in northern Greece, obsidian from the Aeolian Islands off Sicily or the Ponza Islands was also found at the site, suggesting the possibility that boats were used during this period for commerce. Just the fact that early Neolithic and pre-Neolithic peoples sailed around the Mediterranean demonstrates that they had already accumulated a fair amount of expertise.

Asian maritime innovations kept pace with the advances in the Mediterranean. In the eighth millennium before the present, early Jomon navigators guided oceanworthy craft across the treacherous Kuroshio Current, which separates the northern Izu Islands from the southern end of the chain.[25] They made landfall on Hachijo-Jima, 300 kilometers south of Honshu, then part of the Asian mainland. It may well be that they continued on over another 320 kilometers of open sea to visit the Ogasawara Islands. The evidence from Japanese sites also makes it abundantly clear that by 9,000 years ago Jomon peoples were not only using estuarine resources but exploiting tuna and marlin along with other resources from the open sea. Curiously, like early Mediterranean island colonizers, Jomon people carried livestock along on their voyages of exploration.

The discovery of whaling equipment and the remains of sperm, right, and humpback whales at Bangudae, a site in southeast South Korea, attests to a major increase and intensification of maritime skills in eastern Asia by 8,000 years ago.[26] Near the site, etched into a cliff face, are images of whaling activities including specialized whale-hunting equipment and the sophisticated techniques, such as using floats, employed by the early whalers here. These discoveries suggest a greater antiquity of whaling in the western Pacific, as the social and technological complexity necessary to hunt these ocean creatures required a long period of developing these hunting techniques.

At about the time when the Jomon sailors were exploring the Philippine Sea, other Asians, perhaps closely related to the Jomon people or to the Korean whalers, piloted their seagoing vessels farther and farther north, into the Bering Sea. Some eventually made landfall on the Aleutian Islands.

Sites on islands scattered along the rugged, partially glaciated coast of southeastern Alaska have evidence of a long tradition of exploiting the sea and its resources. Nearly 9,000 years ago the residents of Anangula, a site on the Aleutian island of Ananiuliak, were skilled seamen who exploited a wide range of sea mammals, fish, and birds while exploring the Aleutians for other resources, including obsidian from Unmak Island.[27]

Isotopic analysis of the remains of a young man found at On Your Knees Cave, Prince of Wales Island, indicated that his diet was primarily marine foods such as sea mammals and fish.[28] Obsidian artifacts made nearly 10,000 years ago, as in the Old World, document voyages between Baranof and Suemez Island and the mainland of southeast Alaska and northern British Columba.

Farther south, human remains from Arlington Springs on Santa Rosa, one of California's Channel Islands, date to the Clovis era.[29] Non-Clovis artifacts found on Santa Rosa are made of chert transported from San Miguel Island, 15 kilometers to the west.[30] San Miguel is also the location of Daisy Cave, where excavations of a 10,600-year-old occupation level yielded sea birds, seals, eighteen species of marine fish, fishhooks, and sea grass cordage, demonstrating that the technological foundations of a maritime society were in place before the arrival of Clovis people in California.[31]

The east coast of the North American continent had a much different history, but just as trace element studies can pinpoint offshore obsidian sources found in Japanese sites and Franchthi Cave, the movement of raw lithic tool stock provides the best evidence for watercraft.

Clovis people are known to have used exotic or extra-local raw lithic materials exported great distances across several major river drainages before the stones were used and discarded or lost. For example, a Clovis projectile point made of Knife River flint from North Dakota is reported as part of a cache buried in upper New York State, 2,000 kilometers from its source.[32] Pedestrian transportation of these resources is possible, especially parallel to river courses, but foot traffic along river bottoms would be difficult at best. Cross-drainage movement would pose the biggest problems for pedestrian travelers, since major streams and rivers were impossible to wade or swim . . . especially while toting a bag of rocks! The crossings could have been made when the rivers were frozen by winter temperatures, or they could have been avoided with (unlikely) detours around the headwaters, which may have added hundreds of miles to a trip. Most crossings required a boat. Clovis people likely relied on some sort of floating transportation, perhaps including expedient vessels such as bullboats. These were simple, cup-like craft, made with an animal hide pulled over a stick frame, used by many primitive people. They were difficult to steer and usually used only to cross steams.

Of great interest for our argument is the recognition by the archaeologist Steve Loring that a fluted projectile point found on the surface of a former shoreline of the Champlain Sea was made of a stone from Labrador.[33] The Champlain Sea formed when the Laurentide Ice Sheet depressed the Saint Lawrence and Champlain Valleys of New England below sea level. Around 12,500 years ago as the glacier retreated northward, the ice dam blocking the Saint Lawrence River collapsed, allowing Atlantic seawaters to flood the valleys, creating an inland brackish sea that was home to marine mammals such as beluga and bowhead whales, harbor porpoises, and seal species that are frequently hunted by humans. As the glacier continued to melt, the crust it had been depressing began to

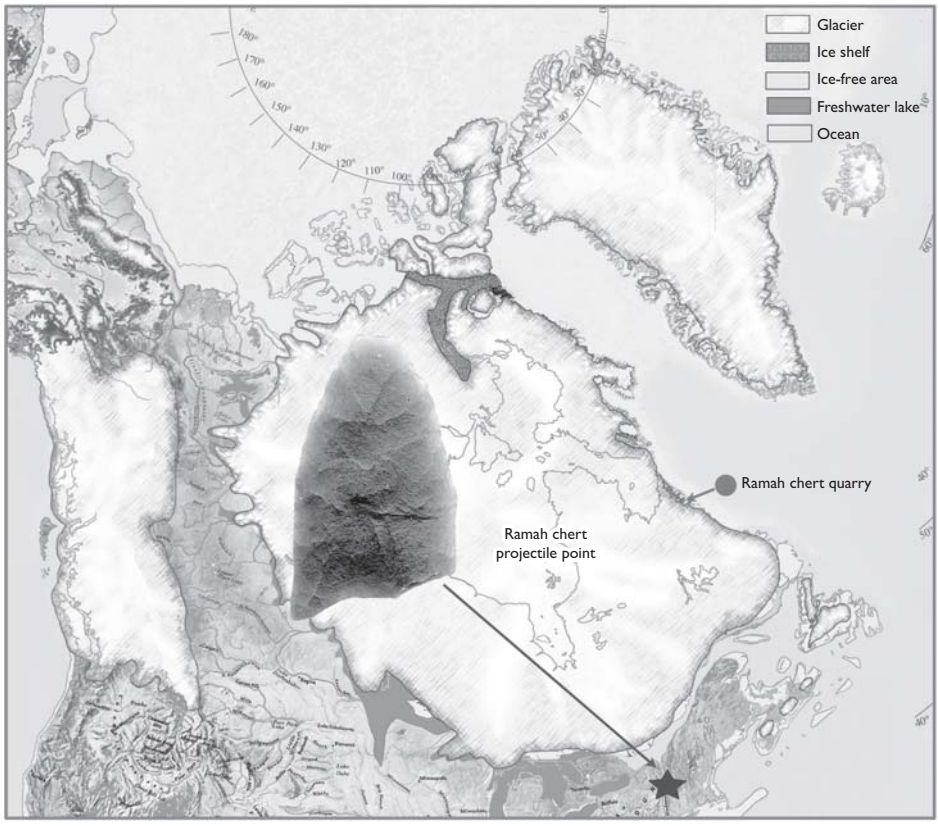

FIGURE 10.1.
Projectile point made of chert from Ramah Bay, Labrador. The point was found on the upper strandline of the late glacial Champlain Sea in Vermont.

return to its previous condition, a process called isostatic uplift, which by 10,200 BP had raised the valleys and drained the sea.

In 1980 Loring published an analysis of more than thirty fluted points associated with a former shoreline of the Champlain Sea in present-day Vermont.[34] He proposed that they had been used for hunting sea mammals in the near shore environments of the ancient sea. One of the points is made of a fine-grained blue-gray material that he originally thought was a variant of the local Cheshire quartzite (figure 10.1).

Loring turned his attention to fieldwork in northern Labrador, where he became familiar with Ramah chert, which outcrops in the Torngat Mountains south of Hamilton Inlet. The Ramah chert reminded him of the fluted point he had thought was made of an "odd Cheshire quartzite." His curiosity piqued by the potential implications of the Paleo-Indian use of this material, he arranged to re-examine the point. His visual comparison of the point with both Cheshire and Ramah stone confirmed that Ramah was likely the source of the raw material. Subsequent laser microprobe analyses confirmed his suspicions.

The straight line distance from Ramah Bay to where the point was found is about 1,300 kilometers. However, following that course would have been impossible, since nearly the entire distance between the two areas was glaciated. Further, most of the Canadian coastline from the Torngat Mountains to the mouth of the St. Lawrence was also glaciated, with tongues of ice extending into the Atlantic Ocean. In fact, at the time the point was made, a boat would have been the only way to travel between the two areas. Moreover, the flintknapper or an intermediary would have had to skipper a vessel with the ability to sail into the wind against the iceberg-laden Labrador current and skirt marine glaciers along a storm-ridden coast with few if any places to make landfall. Following the shortest water route, the distance from Ramah to Vermont is more than 2,400 kilometers.

The most likely scenario is that the Paleo-Americans who made the trip to the Ramah source left not from the Champlain Sea but from a closer port, perhaps in Nova Scotia, the last point of land before the open ocean. Even from that ice-bound remnant of land, the sea voyage would have been a round trip of 1,500 or so kilometers. We doubt that the expedition wintered on the source, as it was a barren, rocky area isolated by glaciers and sea ice for most of the year; hence we suspect that the entire expedition was accomplished during a single summer.

The Ramah chert source is located on the seaward side of the Torngat Mountains, which stand skyward like a beacon towering above the glacier-covered landscape. Our question is, why make such a long and dangerous trip? Did the sailors know the chert was there? Was it a destination point learned from oral history? Was it part of their society's origin story? Or were they simply out exploring along the margin of the ice and sea?

Even those who still believe that Clovis people were the first Americans should not be too surprised that they knew about watercraft. After all, these were clever people who hunted and killed mammoths while exploring the breadth of North America. Boats would have been very useful, especially in the last activity. Moreover, by the time Clovis bands arrived on the Pacific shore of America, boats were in use by the people already living there. So if Clovis people didn't know about boats when they arrived on the West Coast, they would have learned fast!

In some areas of the southeastern United States an archaeological culture known as Dalton succeeded Clovis. Among the stone tools that Dalton flintknappers produced were formal woodworking adzes and distinctive fluted points. Residue studies of their adze blades reveal traces of charred wood, perhaps evidence of the alternating burning and adzing technique used to make board planks and hollow out large logs for dugout canoes.[35] While this is not proof positive that Dalton people constructed dugouts, it is highly likely that they did. The remains of creatures such as swordfish in their middens leave little doubt that post-Dalton eastern Maritime Archaic peoples, who lived in the northeastern part of the United States and southeastern Canada around 5,000 years ago, fished far out to sea. This prehistoric deep-sea fishing tradition once again speaks to the well-established relationship between humans and oceans.

Fifty-three prehistoric dugout canoes were found when Newnans Lake in Florida dried

up during the drought of 2000.[36] Of these, nearly 70 percent date to between 3,000 and 5,000 years of age. Although the canoes are not extremely old, their sheer number is a mind-boggling reflection of what remains to be found in the archaeological record and a sobering reminder of how much maritime archaeological evidence was lost when coastal sites were destroyed by rising sea levels at the end of the ice age.

Some people have surmised that evidence of trans-oceanic migrations in the warm tropical waters of Indonesia 20,000 years before the Solutrean is irrelevant to the ice age North Atlantic.[37] But this discounts the post-development cross-cultural spread of new and important ideas that can move across the globe with lightning speeds, especially when disseminated by sailors. Prehistoric people were clearly exploiting marine resources in colder Pacific waters 30,000 years ago. Unfortunately there is a hiatus in the archaeological record of Paleolithic maritime development between 11,000 and 26,000 years ago because the LGM shoreline sites were inundated when melting glacial ice raised the sea level to its current elevation. It is no coincidence that the first evidence of maritime development worldwide is from 10,000 years ago, give or take a thousand years. Was the sudden appearance of Bell Beaker people on the Baltic Coast an invasion from the south, as archaeologists have long thought? No, they were indigenous refugees retreating southward before rising sea levels. Only underwater archaeology can decipher the cultural events that took place on the continental shelves before the establishment of the modern mean sea level.

ATLANTIC CROSSINGS

Without the distractions of modern life prehistoric human actors studied their scenes, observing the interrelated flows that connected earth, sky, and water. These were the essence of life, to be pondered, to be understood, and to be used in harmony. It must have taken generations to fully appreciate the relationships between the sky and the water. Rising ocean swells and falling tides warn of approaching storms, fog banks reveal hiding ice leads, flocks of screeching birds indicate surface schools of fish. The wind at our back carried them home, and the sun, moon, and stars showed them the trails.

When the climate warmed during the LGM and the polar front shifted northward, the annual formation of landfast ice along the Cantabrian coast became undependable. "A friend acting strangely" is the lament of Inuit elders referring to today's similar weather patterns, as global warming makes their traditional knowledge irrelevant.[38] As the ice edge shifted northward, fragmented and intermixed ice pans temporarily replaced it, but fewer and fewer basking seals likely appeared on the horizon as their habitat receded. New skills and technologies were required to cope with these changes of resource availability. Watercraft, perhaps already in use for hunting the late spring floes, would have to play a larger role as resource catchment areas moved farther out to sea. An alternative taken by many Solutrean people was to fall back on terrestrial creatures to provide the groceries.

Another option was to move along with the ice edge as its annual arrival shifted northward along the Aquitaine-Celtic coastline. By the warmer phases of the LGM there may

have been many bands of hunters scattered along the coast whose families moved out to sea along the ice edge, following the harp seals, great auks, and other animals in their annual migrations. There were eastern and western populations of these animals. The European pods and flocks fed on cod migrating along the ice edge toward Greenland. The western animals followed cod bred in the shallows of the Flemish Platform east of the Grand Banks in a combined summer migration that moved east-northeast, converging with their eastern cousins south of Greenland in mid-summer.

Savvy Solutrean sailors would have known from the behavior of polar bears, as well as birds and foxes that scavenge seal kills made by the bears, that they would find land to the west.[39] They would have noted driftwood floating eastward in the sea current; perhaps the search for a wood source was itself a motivation to find the land to the west. Because of a polar atmospheric condition that produces a visual effect known as an Arctic mirage, hunters following the Canadian seals toward the Grand Banks could have seen the mountains of Newfoundland from 400 kilometers away. This phenomenon—also called superior mirage, Fata Morgana mirage, looming, or *hillingar* in Icelandic—is caused by a temperature inversion: when cold air is under warm air, light from distant objects is refracted in a downward arc, making it possible to see things that are far beyond the horizon.[40] In their experiences navigating along the Celtic shelf, Solutrean sailors would have become well aware of looming and had probably spotted Iceland, with its plumes of volcanic ash, Greenland's high ice cap, and Labrador's tallest mountain.

Once the westward passage was keyed to the mountains looming in the horizon, Solutrean explorers likely made a beeline toward land, knowing that ice of the year would soon be forming and that a winter camp on land would be a pleasant respite from living on the ice. Before arriving on the glaciated shores of Newfoundland they would have been diverted southwest along the ice edge until they encountered a chain of low islands connected by inland passages with lee bays. This island chain includes the Grand Banks, Sable Island, and Georges Bank, now submerged beneath the sea but then a safe haven for winter camping (figure 9.1). Here was a refuge uninhabited by other humans and with ice dynamics and seal populations that were familiar to these people, an ideal area to expand their range of exploitation.

During the following summers and years, hunters would explore these new lands, most likely following the seals back to Europe during their annual migration east along the ice margin. They would have encountered old friends and other people working the ice edge, whom they might have lured with tales of rich resources to join them in the New World. Those who explored northward would discover the unglaciated Torngat Mountains and their treasure of Ramah chert. Southern expeditions would eventually make landfall on Georges Bank. Here were coveted stands of spruce trees, not to mention land animals, and the gateway to the interior lands of the New World.

Eventually the roller coaster climate once again plunged into deep freeze, forcing the polar front back south and covering much of the North Atlantic in a thick mantle of ice. In North America, seals and their predators alike were forced southward into refugia along

the eastern continental coast. Now the new south became an economic windfall, and these Solutrean people were no longer trapped on a narrow strip of land wedged between Europe's mountain glaciers and Arctic seas. Indeed, vast lands opened up to the west, rivers that needed exploring teemed with salmon, and other new terrestrial resources augmented their maritime larder. With these new resources and unclaimed territory, their population grew and continued to expand southward. By the end of the LGM the descendants of those early mariners were well established at least as far south as the Susquehanna and Notaway Rivers of the mid-Atlantic region.

Around 14,500 years ago global warming terminated the LGM, dramatically reducing glaciers and shifting the polar front northward. Worldwide, continental shelves were rapidly inundated with seawater, beginning sequences of local coastal environmental changes. In eastern North America the seawaters that breached the wide, flat continental shelf created vast tidal marshes along the coast. Rivers that cut wide valleys during the LGM filled beyond their capacity, creating estuaries, and some eventually became bays, like the Chesapeake. Early mid-Atlantic people, the descendants of the Solutrean hunters, witnessed dramatic changes to their environment and retreated upstream from the sea level rise. The Arctic sea mammals disappeared from the seascape, but they were replaced by other species. Mammoths and mastodon, horses and bison—animals whose images were long before painted on cave walls by Iberian ancestors replaced sea mammals and were once again the primary prey. Darts tipped with detachable foreshafts and end blades were found to be as lethal to terrestrial animals as they were to sea mammals (figure 7.5).

The evidence from La Riera Cave supports the general outline of this model (see chapter 8). The formation of landfast ice likely began during the onset of the cold, dry climatic phase recorded in levels 4, 5, and 6. That climate, which presumably displaced people toward northern Spain, was also responsible for the establishment of sea mammal rookeries in the Bay of Biscay. This convergence acted as a balance, and the local people's exploitation of new economic opportunities seems to have allowed for population expansion with minimal stress or hostilities. The nutrition gained from fatty oils and other nutrients derived from sea mammal consumption not only significantly aided survival during the coldest phases of the LGM but also ensured the reproductive success of the Solutrean people living in northern Spain.

La Riera's level 7 registers a clear shift in economic and residential strategies. Although there are plenty of possible explanations for the change, we suggest that the underlying cause was the onset of an LGM warming phase that rendered the annual landfast ice unpredictable. By level 8 there were marked changes in tool kits and site functions from those of levels 4–6. In fact, the previous occupants may have abandoned the area, since several new point styles were introduced into the cave debris. The change of use of La Riera Cave may well signal that some of its former occupants elected to follow the ice northward along the Aquitaine coast. The replacement population keyed in on the red deer as their primary food source.

CONCLUSION

This book has been a personal and professional journey for both of us. It has taken us from the mainstream to the position of attempting to broaden the search for evidence of the earliest colonists of North America beyond the northeast Asian unilineal model. This work began as a concept book in which we hoped to elucidate an old idea, elevating it to the level of theory. We arrived at this position from different directions but with a common experience, the investigation of Clovis sites and materials. Bruce came to the idea the way others have in the past century, seeing similarities between some Upper Paleolithic artifacts and Clovis artifacts while doing archaeology in southwestern Europe. Dennis came to it by recognizing the lack of Clovis precursor technologies while working in Alaska. Individually neither of us had strong enough evidence for challenging the theory of a Beringian origin for Clovis. Together, we think we have forged a solid basis for just that challenge.

As we began to formulate our theory and to inventory the plethora of evidence that we would have to examine and evaluate, we realized that the book would have to be more than ideas. It would have to be based on sound information. This of course meant that we would have to do the research.

That we have put this study together now, and that it seems to be of current interest, is no coincidence. Archaeology is in a period when new discoveries and re-evaluations of old work are being generated at an astounding rate. Even as we finished our manuscript, new models of the North Atlantic environment during the Last Glacial Maximum were being proposed. New and exciting work is being done in western Beringia, and Alaska

is witnessing increased archaeological exploration. Some Beringian sites have been redated, such as Ushki, which has been taken out of the running as a possible Clovis progenitor. Recent work with fluted point sites has shown them to be younger than Clovis, and the lowest level at Swan Point, the oldest site yet found in Alaska, is clearly linked to the Late Dyuktai culture of western Beringia. At the same time, five sites—Meadowcroft Rockshelter in Pennsylvania, Cactus Hill in Virginia, Miles Point and Oyster Cove in Maryland, and the *Cinmar* discovery on the outer continental shelf near Chesapeake Bay—significantly predate Clovis and overlap with the Solutrean.

The past decade has also seen a new openness and sharing of the archaeological information from the Russian Far East. Works previously unknown in the West have become available. Many have been translated into or summarized in English. We have gained access to not only the collections and reports but also our Russian counterparts, with whom we maintain active dialogues.

Clovis archaeology has been enhanced by the discovery of new sites, especially those in the southeast and Texas and on the eastern shore of the Chesapeake Bay, that have changed our views about the complexity of Clovis lifeways. The past couple of decades have also been a time of giant strides in the study of flaked stone technology. Understanding its intricacies has given us a whole new area of behavior to throw into the mix. The list of recent advances goes on to include new methods of tracking human genetic relationships, reconstructing ancient environments, finding evidence of early textiles in burned clay, and developing more reliable dating methods, to name but a few.

But despite all that is new and exciting, we have been disappointed in some areas where little progress has been made in the past fifty years. Probably the greatest surprise to us has been how little new research has been done on the French Solutrean. The collections we examined were from the early decades of the twentieth century, with a couple of important exceptions. Even in recent literature, the discussions about the Solutrean are little different than they were when Bruce was working in southwestern France more than thirty years ago. We have relied heavily on the work of Spanish and American archaeologists in northern Spain and a team of international researchers in the Claise Valley of France. They have investigated and continue to investigate well-stratified sites, applying the most current methods.

We recognize that the idea that Clovis may have had a European ancestor is not new, but in view of recent advances we disallow the conclusion that it has been adequately tested, and rejected. We hearken back to a statement by a pre-eminent southwestern archaeologist, T. Mitchell Prudden, who in the first decade of the twentieth century described the Pueblo archaeology of the Four Corners region as a "sucked orange" with nothing important left to discover.[1] There are several generations of southwestern archaeologists, and a fascinated public, who would beg to differ!

The following are the conclusions we have reached in our various areas of inquiry. Although we contend that flaked stone technology is a better indication of historical connections than tool form, the profession has not embraced this assertion in general. Never-

theless, we think that the common assumption that technology was mainly an adaptation to specific needs and would be easily changed by a group is also unfounded. Indeed, we have only to look at what was done with some of the major technologies, such as microblade, to demonstrate the fallacy of this notion. Microblade tools and technology dominate archaeological assemblages at one time or another in every ecological zone, from the Sahara desert to the high Arctic.

We contend that the more basic a technology, the more likely its independent invention. By the same token, we conclude that complex technologies that shared highly detailed and specific methods were unlikely to have been independently developed. The possibility of their historical relatedness would of course depend on a plausible link in time and space. Since this exists for Solutrean, pre-Clovis, and Clovis, we conclude that the high degree of correspondence between their flaked stone technologies indicates a historical relatedness.

It is an amusing coincidence that a Frankish king indirectly lent his name to such a contentious issue in North American archaeology! Based on its appearance in textbooks, Clovis is probably the best known ancient culture in the Americas, but do we really know much about it? We think not. The popular image of a specialized mammoth-hunting society, meandering around the semi-arid west, is giving way to a much more interesting story. For instance, we now see that small animals—including fish, reptiles, and amphibians (and their eggs)—and nuts and berries made up much of the Clovis diet.

We have also become aware of large, long-term habitations where Clovis folks settled, built structures, and produced objects of portable art. Settlement was densest and probably longest in the east. The Gault Site in Texas and a late radiocarbon date of 10,765±25 from Jake Bluff in Oklahoma hint that Clovis occupation crossed the animal extinction boundary at the end of the last ice age. This indicates that Clovis was probably longer lived than we thought.

Rather than being adapted to a single environment, Clovis ranges from subarctic to subtropical climes, with no change in flaked tool technology or inventory. Based on where Clovis finds have been made and the origins of identifiable stones at these sites, Clovis folks were consummate explorers.

Although we have found little evidence of Clovis art other than a few engraved bones, ivory objects, and pebbles, their knappers were extraordinary artists. Their flaking went well beyond what was necessary to make a functional tool, and they left behind caches of some of the most beautiful pieces of flintwork seen anywhere. It is clear that Clovis came from a deep, rich heritage and expressed some of this in a formalized flaking tradition. Clovis people's technique of thinning the bases of spear points, known to us as fluting, is unique in the world, was practiced and perfected by their descendants, and then vanished.

In archaeological terms, Clovis sprang into being, spread throughout North America and into South America, and gave rise to innumerable regional cultures around 13,000 years ago, at the dawn of the Holocene. Who were these people? How could their culture

spread so quickly in 200 or so years over such a vast region with little to no change? And where and who did they come from?

There is only a small amount of evidence of people in North America before Clovis. Surprisingly, it is not in the northern Great Plains, where theories have predicted it would be. Most of the earliest evidence comes from eastern North America. The sites in the Chesapeake Bay predate all of the archaeological remains documented in eastern Beringia, and they overlap with the Solutrean in southwestern Europe. More early deposits are being encountered on the eastern shore, and tantalizing finds are being made on the deeply submerged continental shelf. There are also strong hints of earlier humans in the lower Great Lakes region, and new possibilities are cropping up in the central plains. As more early sites are validated and documented, we will get better at predicting where additional ones should be and will undoubtedly find more. The recognition of these early artifact types by professional archaeologists and amateur collectors alike will also lead to new discoveries.

Our evaluation of the Beringian data is that there is no evidence of Clovis ancestors in Siberia. The oldest fluted points in Alaska are younger than western Clovis and much younger than the early sites in eastern North America. Even if we discount these dates, there are no good technological candidates for a thinned biface, large blade tradition in Beringia. Beringia today, especially on the Asian side, is one of the coldest and most inhospitable places on earth. Only Antarctica rivals it. Imagine what it must have been like during the even colder and stormier glacial period. And this is where we expect to see intrepid waves of migrants in search of a better place to live? Perhaps some did penetrate into the area, but not on a large scale until after the LGM.

It is generally agreed that Denali, the oldest dated culture of Alaska, is directly derived from the Dyuktai culture of northeastern Siberia. We concur with this conclusion, but upon what is it based? It is the similarities between the two assemblages and the slightly older dates for Dyuktai. This makes good archaeological sense. So why not use the same criteria to identify an ancestral Clovis culture? Our comparisons of these assemblages clearly indicate there are few similarities between Clovis and either Dyuktai or Denali, but there are a great many similarities shared among Clovis, pre-Clovis, and Solutrean technologies and tools.

There is increasing evidence that a habitable land route through the northwest American ice-free corridor was not available before Clovis times. When a passable corridor did open, the evidence points to people moving northward up the corridor when it opened rather than the other way around. We contend it is even likely that people moved through eastern Beringia into northeastern Asia, taking with them a modified continental North American technological tradition like Sluiceway.

It is possible that, just like the North Atlantic at the end of the ice age, the North Pacific Rim may have served as a route of migration. Research is proceeding along these lines, and there is some promising evidence of a coastal migration that reached southeastern Alaska and western Canada. It is also highly likely that maritime ancestors of Kennewick Man traced their origins to southeast Asians who explored the North Pacific during the

LGM. Of course, wherever we look, be it North Atlantic or North Pacific, we must keep in mind that the best evidence is undoubtedly below the waves on the continental shelves. This is also true in southwestern Europe.

Based on the archaeological evidence we now have, we see multiple movements of people in Beringia at the end of the Pleistocene. The first is traced by the Dyuktai-Denali Complex, which spread from east central Siberia into Alaska, then the Cascade Mountain area of western Canada, and possibly even the northern Great Basin of the American west. The second is a migration of peoples from the Russian Far East who arrived in Alaska in the early Holocene. The third is a movement in the opposite direction: Paleo-American peoples traveled up the expanding ice-free corridor to Alaska's North Slope and Nenana Valley, then possibly moved into western Beringia.

If Clovis ancestors did not come from Asia, what other cultures were around that may have been their progenitors? We have looked east and found a very suitable possibility in the form of a biface-thinning, large blade tradition perched on the edge of the Atlantic Ocean at the margin of the southern extent of the sea ice during the LGM. This archaeological culture has been dubbed Solutrean.

After we decided that the often dismissed idea of a Solutrean origin for Clovis merited more intense scrutiny, we made two extended trips to France and Spain, in 1999 and 2000. We also delved into as much literature as we could get our hands on. (Both of us can read technical literature in Spanish and French.) The main thing we found was that there is no one Solutrean. It is really a mixed bag, with technological differences through both time and geographic regions.

Collections from Solutrean sites, especially in France, suffered greatly because the sites contained beautiful artifacts. These artifacts were highly sought after and excavated in the early years of Paleolithic archaeology. Few French Solutrean sites have been investigated with modern techniques, and few of these collections are available that contain both large numbers of items and good records, Les Maitreaux being a notable exception.

Another peculiarity of the Solutrean is that all but a small number of the known sites are in rock shelters or caves. This is partly because that is where archaeologists looked, but there also seems to be a geological explanation: open sites have been deeply buried, as in the Landes area, inundated by the sea, or destroyed by erosion. Whatever the reasons, it is clear that we are looking at only a sample of the sites Solutrean folks left behind, and all of them are inland.

There has been great debate about where the Solutrean came from, with little resolution. One camp argues for an in-place invention and points to a few developmental technological traits in early assemblages. The other camp dismisses these as insignificant and sees the Solutrean arriving in southwestern Europe as a fully developed culture, but from an unidentified location. This sounds a lot like our Clovis origin debate.

Even with all of these problems, most researchers agree on a few basic points and have noted some extraordinary aspects of the Solutrean. To begin with, there is general agreement that the flaked stone technology of the Solutrean was based on large blade and thin

biface manufacture, unlike the technologies of the Paleolithic cultures that came before or after. Most agree that these people lived in a relatively restricted area with no apparent geophysical boundaries in some directions. Unusual inventiveness and adaptability have also been ascribed to the Solutreans. It seems to be they who invented the spear thrower, heat treatment, and, at least in their Mediterranean expression, the bow and arrow. Whether or not Solutrean folks actually did invent all of these things, they certainly incorporated them into their culture in ways never seen before in the region.

Many researchers have pointed out how adaptable Solutrean people were in order to make their living in the extreme ice age climate, especially in the upland areas. More than one archaeologist has noted that they were general foragers as well as hunters and the first to really exploit the sea margins, at least in western Europe.

We can see that Solutrean people were part of the general Upper Paleolithic spiritual-artistic tradition in their excellent cave paintings and engravings. They also added new elements to their art through the selection of colorful exotic stones to make tools, especially the exquisite oversize, ultrathin laurel leafs that were buried in caches, a previously unknown behavior.

This was a vigorous culture whose roots were deeply embedded in the general Upper Paleolithic but that certainly marched to a different drummer. Its seemingly abrupt appearance in and disappearance from the archaeological record may be less real than it seems. In many places Solutrean deposits are truncated by erosion, and it is unclear how long their culture may have lasted. However, even in the areas where it held sway for perhaps several thousand years, we see little vestige of its existence in the cultures that followed, at least in southwestern Europe.

We have discussed at length the difficulties archaeologists face when trying to establish historical links between what are essentially made-up ancient cultures. Our research tools are limited and for the most part revolve around connections in time, space, and archaeological remains interpreted through theoretical frameworks. With few exceptions, Paleolithic archaeologists have precious little to work with—no written records, no first-hand accounts, only the wordless things we find and the deductions we make from them.

There are a number of ways that we can come to some conclusions, but in almost all cases they involve direct comparisons. Comparing assemblages or archaeological cultures is at best a tricky exercise and at worst an exercise in self-fulfilling prophesy. We can decide what we want to conclude and then compare just those traits that support our contentions. The worst results of this approach are the ever-popular trans-oceanic theories of Vikings in Minnesota, Irish monks in New Mexico, and even space aliens in Yucatán.

We admit that we have selected certain traits and not others for our comparisons. But we have striven to base these selections on comparability between complete bodies of data, not only on what we thought might be fruitful. We have also chosen to use a statistical method, cluster analysis, to objectify the comparisons, knowing full well that at best this method would only weakly support or contradict our subjective assessments. Nev-

ertheless, our cluster analyses have lent support to our interpretations of similarities and differences between assemblages.

Whatever methods archaeologists apply, using whatever variables, it is paramount that we apply the same criteria in all situations to investigate relatedness. We find it curious that colleagues will discount the importance of similarities between two assemblages in one case, citing coincidence and independent invention, but then use exactly the same approach with other assemblages, find even fewer similarities, and conclude that there is good evidence of relatedness.

Among the most frequent criticisms against the idea of a Solutrean origin for Clovis are: there is too large a time gap between the end of the Solutrean and the beginning of Clovis; there is no way Paleolithic people could have dealt with the harsh ocean conditions of the last ice age; and there is no evidence that they had boats. We think that all of these suppositions can be reasonably challenged.

Meadowcroft, Cactus Hill, Miles Point, and Cinmar, along with other likely early sites in North America, should finally put to rest the time issue. There is no longer a chronological gap between the Solutrean and the earliest sites found on the East Coast, but one still exists between the early North American evidence and Clovis. However, sites such as Jefferson Island, Page-Ladson, and Johnson indicate that this gap will close as well.

When we compare the difficulties of traversing a high Arctic landscape in the coldest place on earth on foot to those of traveling along an ice edge in a small craft, even in an ice age ocean, we think that traveling on the sea in sub-Arctic latitudes would be more feasible. Even Beringia would have been all but impossible to get across without some type of boat. The glacial melt and outwash in the summer would have made for massive river systems that, although smaller today, are still daunting to cross. Of course, people could have waited for the rivers and marshes to freeze over, but then they would have been traveling through a frozen landscape in short daylight and prolonged darkness with reduced or unavailable resources.

Still, to most people today, crossing the North Atlantic at the height of the ice age would seem to be more difficult. To investigate this, we pulled together the paleoceanography information that is currently available, but this area of research is extremely active, and major changes in interpretation are frequently published. As in any other field of science, there are significant disagreements, and debate about the extent of the ice front and how to assess productivity is the order of the day. Unfortunately, the story of the *Titanic* has overly influenced the public conception of the North Atlantic. How could "simple" Stone Age people successfully take on such a hostile environment when even our modern technology can so obviously fail?

We have to completely discard our preconceptions on this point. Although we do not suggest a direct analogy, seeing how historically documented Arctic people have adapted and coped has certainly been enlightening. What we consider hostile, Inuit people consider idyllic. What we think of as impossible, they accept as normal. Their technologies

for survival in a cold marine environment are ingenious to us, but archaeologically their nonperishable tools are relatively simple. It is not reasonable to think of Upper Paleolithic people as being any less intelligent than modern people—they just had different survival issues to contemplate. Why is it so hard to imagine Solutreans figuring out ways to take advantage of the North Atlantic environment?

The issue of boats is one more of preservation than possibilities or human abilities. There are any number of places around the world where indirect evidence of boats is clear but direct evidence is lacking. Few people would dispute that Micronesia, Polynesia, and Australia had to be colonized by seafaring people, but where are the archaeological watercraft? We find it inconceivable that people as clearly innovative and inventive as the Solutreans would have been unable to come up with the concept and make boats adequate for their needs, be they on glacial rivers or sea margins. In fact, if archaeologists ever develop methods to identify boats in the ancient record, we are sure they will discover a deep history, perhaps as far back as the Lower Paleolithic.

The majority of the oldest dated sites in the Americas with undisputed artifacts are in the Chesapeake Bay region. The artifacts from these LGM sites are technological and functional equivalents of artifacts from the same period found in southwestern Europe and are not technologically or morphologically related to any east Asian technology. These facts, along with the lack of any possible antecedents of the Chesapeake Bay sites in the rest of North America, indicate that the most parsimonious conclusion is that the early American Paleolithic technologies have their origins in southwestern Europe and that opinions about the productivity of the LGM North Atlantic relative to human exploitation need to be re-evaluated, along with ideas about maritime development and oceanic travel.

As to direct evidence of the origins of specific groups of people, we suspect that future DNA studies will identify which Old World populations came to the New World and when they arrived. Developments in genetic research have already contributed some intriguing hints of the European origin of early American cultures. But for now, these studies are fraught with difficulties—most are based on modern DNA, results from the analysis of a few pre-Columbian individuals, and even fewer Paleo-Indian readings.

At present no undisputed remains of Clovis or Solutrean people have been found to provide genetic data for comparisons; thus, grand schemes that link the earliest Americans to either Asia or Europe via DNA evidence are at best only speculation. A mitochondrial genetic marker known as haplogroup mtDNA X has an intriguing distribution: evidence of this haplogroup is found in early pre-Columbian remains in eastern North America, but it does not occur in Asia in prehistoric times or east of the Altai Mountains in modern times. When fully understood, the X haplogroup may provide evidence of early pre-Columbian origins in Europe. The preconceived notion of geneticists and archaeologists that the Americas must have been settled by Asians has produced interesting models to get the Paleolithic X marker out of Asia without leaving a record in the modern eastern Asian population.[2]

The distribution of the X haplogroup suggests that it is very old. Within X there are two major branches, X1 and X2.[3] X1 is restricted to North and East Africa and the Near East. X2 is found in North Africa, Europe, the Near East, and central Asia, and there is a trace of it in some North American populations. Carriers of X2 are thought to have expanded into Eurasia through the Near East at or near the end of the LGM and therefore would not have been present to add to the North American gene pool before the end of the LGM.

Native American X2 sequences have a further distinctive branch, known as X2a, which is not found outside the New World. Hence, it may represent the very early split of a population that had a limited distribution in western Europe and did not spread eastward. Traces of X2 are found in both living and prehistoric Basque populations, which are thought to be the descendants of Paleolithic Europeans.[4] X2 also occurs among people of the Orkney Islands, an area that was part of the unglaciated North Sea shelf during the LGM. The discovery of LGM sites on the eastern shore of North America and the prehistoric occurrence of the X2 haplogroup in eastern North America suggest that scholars should consider a model of Paleolithic people carrying the X2 haplogroup into western Europe and eventually into the Americas during the LGM. It is interesting that the occurrence of mtDNA X among modern Native Americans has a distribution pattern similar to the occurrence of late Pleistocene sites, with the earliest occurrence and the highest incidence of both in eastern North America and progressively lower ages and incidences toward the west (figure 11.1). Is this only a coincidence?

To sum it all up, we contend that the archaeological evidence that Clovis predecessors were immigrants from southwestern Europe during the LGM is stronger and more compelling than the evidence that their ancestors were from an Asian microblade tradition that came out of northeastern Asia at the end of the LGM. This is based on dating, comparisons of archaeological assemblages, and environmental reconstructions. Sometime during the last glacial epoch, a biface-thinning, blade-making culture figured out how to exploit the marine environment that was present along the ancient strands and ice edges off southwestern Europe. This may have been a small segment of what is known to archaeologists as the Solutrean. But not all Solutrean people or periods would have been represented in this founding group. We see them as deriving from the middle Solutreans (possibly between 19,000 and 23,000 years ago), who probably inhabited the area along the north shore of the Iberian Peninsula and the western shore of the continental shelf that stretches from southwest France northward along the British Isles, most of which is now under the ocean. These people adjusted their technologies and lifeways to exploit a marine environment, and through generations of exploration some found their way across the North Atlantic to make landfall in northeastern North America. We do not envision an immediate rush of immigrants to colonize the newfound lands. Why would people who had adapted to an adequate marine environment suddenly abandon it for the unknown promise of yet another impoverished terrestrial landscape? As long as the polar environment persisted, we see people focused on the ice edges, tethered at each end by

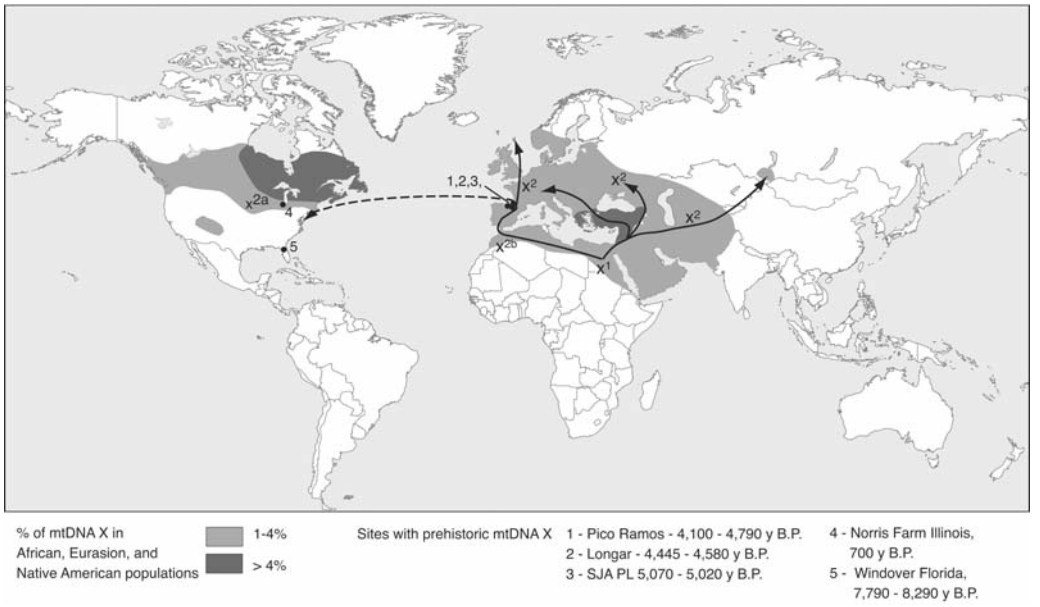

FIGURE 11.1.

World map showing haplogroup X mtDNA distributions. (Data from Izagrirre and de la Rua 1999; Brown et al. 1998; Reidla et al. 2003; Schurr 2000; Schurr et al. 1998; Smith et al. 1999; Stone and Stoneking 1998.)

land. Solutreans expanded their territory to include the ice edge, eventually incorporating the eastern shore of North America; they didn't migrate as a group to the New World.

The durable tool kit of the founding Solutrean population in North America would have included both biface and large blade tools and a range of bone, antler, and ivory tools. The perishable material culture probably would have amazed us: it would have included cold weather and water-resistant tailored clothing, substantial portable dwellings, and boats.

As people settled into the New World, we see explorations up rivers and changes in how they made their living as the Pleistocene wound down. Perhaps for a long time, some people maintained a sea margin lifestyle, moving back and forth between the continents. Their base sites would have been mostly along the now submerged coastlines. Climatic changes at the end of the ice age caused the glaciers to melt at a rapid rate. Meltwater from coastal and marine glaciers drained directly into the oceans, while meltwater from terrestrial glaciers collected into massive lakes behind retreating glaciers. Around 14,500 years ago, shortly before the advent of Clovis, receding glaciers opened up lowland channels, such as the Saint Lawrence waterway that drained the lakes and released massive amounts of water into the seas, causing sea levels to rise nearly 20 meters in 300 years. The rapid sea level rise no doubt reduced the productivity of coastal resources and pushed Paleolithic populations inland. The traditional ice edge exploitation of the North Atlantic became less and less tenable or desirable. The Magdalenian replaced the Solutrean in

southwestern Europe as the populace in the New World was cut off from its ancestral homeland. While this may have happened relatively quickly in geological terms, the effects on individuals would have been less obvious. As the North Atlantic became more difficult to exploit and traditional areas were inundated, Solutrean peoples may have gravitated toward the western edge of their territory, leaving sparse representation on the European side, which eventually absorbed them into its shifting cultural scene.

The archaeological evidence suggests to us that there were at least two technological adaptations to North American climes. One was the progenitor of Clovis: the people who used it continued to focus on littoral resources and worked their way down the East Coast, eventually spreading into Florida and possibly even the West Indies. Whatever the impetus, Clovis then developed in the southeast and colonized the region by traveling up the rivers and around the western edge of the Gulf of Mexico.

The second adaptation stuck to the edge of the retreating glaciers. It may have followed the glacial front to the west, producing the Meadowcroft and Chesrow evidence and eventually developing into the Goshen Complex of the northern High Plains, the Plainview Complex of the southern High Plains, and perhaps the Nenana of Alaska. When Clovis people explored the west, these people were already there: Goshen in the northern plains and descendants of Denali and other Asian peoples in the Great Basin and the northwest. There are many scenarios of how they might have interacted as friend or foe. The key element of the later colonization of the New World is that people continued to arrive from Asia, but the European route was cut off. There would be no more genetic input from across the eastern ocean for at least ten millennia.

The ideas in this book are not intended to be an explanation as much as a set of testable theories to help guide future research. If we have learned anything during this study, it is that thinking we know much about the archaeological cultures we so blithely speak about and use as the bases for our interpretations is the utmost arrogance. We are convinced that researchers continually underestimate the abilities, the vision, and the intelligence of our ancient cousins, whether in the east or the west.

So what's next? We don't see a major change in the way archaeologists explore for new evidence of ancient cultures. The main modifications we contend have to be made are to open ourselves to new possibilities and to develop underwater exploration of the continental shelves. Let us allow the data, in concert with theoretical development, to guide our research. There are many new lines of research developing right now, some of which will undoubtedly result in dead ends. Yet others, even some now considered to be completely crazy, may be just the approaches that will result in the next renaissance in the search for the predecessors of the earliest Americans.

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ACKNOWLEDGMENTS

During the 1990s, new archaeological discoveries and changing ideas about ice age environments caused us to become skeptical of the traditional yet unsubstantiated hypothesis about New World origins. In light of new data, we thought it was important to consider evidence for alternative hypotheses. In particular, we wanted to evaluate the significance of the degree of technological similarities between Solutrean and Clovis artifacts to see if there was enough evidence to justify pursuing a hypothesis of a historic relationship between these two archaeological cultures. Our aim was only to write a short paper and stir the pot. However, we are especially indebted to Doris Kretschmer, a former acquisitions editor at University of California Press, who heard a talk by Dennis about the Solutrean-Clovis connection at the California Academy of Sciences in 1999 and, along with William Woodcock, a former acquisitions editor for Academic Press, convinced us to take on the issue fully. This book owes its existence to their encouragement.

Funding for such a cutting-edge project was not available through normal academic sources, hence we are extremely grateful to Randy Best, Katherine Dimancesu, Jeff Meyers, and Tom Lennon and Charles Wheeler at Western Cultural Resource Management, who helped provide the necessary funds to conduct our research. We were blessed to have an excellent photographic record of our research by the late Chip Clark, the National Museum of Natural History's exhibits photographer. Marcia Bakry, the illustrator for the Department of Anthropology at the National Museum of Natural History, produced all of the detailed artifact illustrations and maps. Ted Timreck, of Timreck Production, New York, produced video documentation of the research. Maggie Dittemore, librarian in the Department of Anthropology at the National Museum of Natural History, was most helpful in locating hard-to-find manuscripts and publications. We are deeply appreciative of the advice and comments of our col-

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Special appreciation is due to the incomparable Juliana Froggatt for her ability to bring metamorphic change to our manuscript so that it is now easily readable. We are grateful to Blake Edgar, the acquisitions editor who took on our book after Doris left UC Press, and our sainted project editor Dore Brown for their help and patience bringing the project to fruition. Editorial coordinator Lynn Meinhardt and acquisitions coordinator Hannah Love deserve our deep gratitude, along with Alex Dahne, who will see our collective works gain maximum visibility.

We received valuable assistance from many scholars who helped us at the National Archaeological Museum in Madrid, the Prehistoric and Archaeological Museum of Cantabria in Santander, the Museum of Altamira, and the Archaeological Museum of Asturias in Oviedo in Spain; the National Archaeological Museum of Lisbon in Portugal; and the National Museum of Prehistory in Les Eyzies and the Museum of Prehistory in Solutré in France. We are deeply grateful to the scholars and staff at these museums for sharing their Solutrean collections and knowledge; without them we could not have conducted our research. We are likewise indebted to Darrin Lowery, who generously allowed us access to his collections from the Eastern Shore of the Chesapeake Bay and provided some maps and photographs.

Bruce wants to acknowledge the many people who had an early, profound impact on his interest in knapping and technology. François Bordes served as his mentor and friend and introduced him to Solutrean and Old World technologies. Don Crabtree, J. B. Sollberger, Bruce Huckell, Jacques Tixier, Evgenia Giria, Thierry Aubry, Bertrand Walter, and Jacques Pelegrin have greatly influenced his knapping and have always encouraged him to stretch his thinking. His early endeavors at applying knapping knowledge to archaeological questions were supported and promoted by Marie Wormington, Art Jelinek, George Frison, Dennis Stanford, C. Garth Sampson, Charles McBurney, Mike Collins, Hizri Amirkhanov, Sergey Lev, and countless others. All of these colleagues have his profound gratitude. Whatever they think of this work, their help, support, and guidance have influenced Bruce to continue his explorations into the application of technology to archaeological questions.

Dennis offers his loving thanks and appreciation to his wife, Pegi (Margaret) Jodry, who supported not only Dennis but the fifteen years of research as well. She also provided excellent ideas about the direction of the research and subject content and helped assemble the database used in the analysis. Moreover, she is an articulate proponent of alternative hypotheses. Thank you, Pegi.

Finally, we are extremely grateful to all of those people who have listened patiently to our theories and evidence for the ice age Europe origins of some people in the New World. Supporters have encouraged our investigations, and critics have ensured that we extended our research and presented solid evidence. We are greatly appreciative of the Smithsonian Institution and the University of Exeter, which have employed us throughout this long and interesting intellectual journey.

APPENDIX

CLUSTER ANALYSIS

We did two cluster analyses, the first to see how the method would work with the kind of data we had, and the second to test our ideas about possible historical connections. Cluster analysis takes numerical data in the form of space-delineated columns and rows and runs varied comparisons on them. The output is known as a dendrogram. We particularly like this graphic because it is easy to visualize the relationships between categories, and the categories are not influenced by the order in which the program receives the data: the program, not us, identifies the clusters. It is of course gratifying when groups of items that we think are similar end up in the same cluster and equally welcome when those we see as different are in different clusters. But it is also possible that assemblages may cluster in unexpected ways. Such cases challenge us to look at the data with fresh eyes to search for explanations and help us to see around some of our biases.

U.S. SITE COMPARISON

Our first application of cluster analysis was to generate a table of U.S. fluted point assemblages by tool type proportions. The expectation was that if all of the sites were historically related and had the same function, they would cluster tightly together. In most cases, we used the published categories and counts, but on occasion it was possible to do some minor reclassification based on illustrations. Our greatest challenge was to identify artifact types shared by most of the site reports available to us, since different researchers had used different typologies. For example, in some reports bifaces are identified as preforms, in others as knives, and in still others simply as bifaces. The obvious thing for us to do was to always choose the simplest type category used in all of the analyses. Unfortunately, this ended up degrading the pos-

TABLE A.1 Tool Type Proportions of U.S. Fluted Point Assemblages

	Tool Type %*							
Site	Point	Knife	Side scraper	End scraper	Drill	Graver	Uniface	Preform
Adams	0	0	8	3	0	5	5	79
Adkins	2	0	12	21	0	61	4	1
Agate Basin Folsom	2	4	25	15	15	0	13	26
Anzick	9	0	3	3	0	0	0	86
Aubrey	13	0	3	22	0	22	41	0
Blackwater Draw	22	14	32	5	0	6	21	0
Bullbrook II	1	0	3	34	0	4	53	5
Cactus Hill	24	0	19	19	0	19	19	0
Cattle Guard	33	2	3	11	0	4	44	3
Colby	80	0	20	0	0	0	0	0
Cooper	91	0	7	0	0	0	0	0
Debert	3	1	19	45	0	3	28	0
Dent	100	0	0	0	0	0	0	0
Domebo	60	0	40	0	0	0	0	0
Drake	100	0	0	0	0	0	0	0
Escapule	100	0	0	0	0	0	0	0
Fenn	37	0	0	0	0	0	0	63
Fisher	5	0	1	5	7	11	44	26
Folsom	100	0	0	0	0	0	0	0
Hanson	7	4	23	17	0	8	38	3
Kimmswick	50	17	0	0	0	0	0	33
Lange-Ferguson	100	0	0	0	0	0	0	0
Lehner	65	0	20	0	0	0	15	0
Lindenmeier	13	10	45	14	0	1	0	17
Linger	60	0	14	20	0	3	0	3
Miami	75	0	25	0	0	0	0	0
Michaud	18	0	20	16	0	0	36	11
Murray Springs	38	15	6	8	0	6	27	0
Naco	100	0	0	0	0	0	0	0
Reagen	30	4	19	29	0	3	11	3
Shawnee Minisink	1	3	14	78	0	0	4	1
Sheaman	14	14	43	0	0	0	29	0
Shoop	13	0	24	57	0	2	0	3
Simon	17	0	0	0	0	0	0	83
Thunderbird	0	0	7	8	0	2	58	25
Vail	3	0	3	15	2	17	59	1
Williamson	3	0	32	48	0	0	8	8
Zapata	86	0	0	0	0	0	0	14

* Proportions have been rounded to whole percentages, which occasionally equal greater or less than 100.

sible comparisons to the point that they were almost useless. We ended up running our cluster analysis on tool type percentages rather than raw counts. This equalized the assemblages so that clustering would not result simply because of large and small numbers of artifacts. There are many ways to manipulate data within cluster analysis. We tested several different combinations and found that the general order and clustering did not change. In this and the following analyses we used squared Euclidean distance for our proximity indicator and mean proximity as our clustering method.

Table A.1 shows our tool type categories from selected fluted point assemblages along with percentages by site. Although there are reports for other sites, they either lack totals for each tool category or contradict one another. We preferred to use original site reports but on occasion deferred to other accounts because they had more comparable categories or gave actual frequencies.

The results of clustering fluted point sites are indicated by levels, which indicate the degree of correspondence. At level 1 all sites cluster. At level 2 there are two major clusters. At level 3 a cluster of four sites breaks out of the main cluster, and at level 4 four distinct clusters are apparent. It is not surprising that in most cases the clusters seem to distinguish site functions and conform well to the interpretations of their investigators. The four functions are habitation (six sites), camps (sixteen), kill site/camps (twelve), and caches (four).

There are a couple of exceptions explained by special circumstances. The Adams Site, a stone-processing locality with bifaces mostly fragmented during manufacture, clusters with caches simply because of its high proportion of bifaces. But although caches have high proportions of bifaces, most of them are complete, not fragments. Accordingly, a further site function discrimination might be possible if we could distinguish between complete and broken bifaces. Unfortunately, many site reports do not give such information. Another exception is the Drake Cache, which clusters with kill sites even though it is clearly a cache. This is explained by the fact that the cache contained primarily projectile points, as did most of the kill sites.

At the sixth level of clustering, campsites separate into two groups, generally those in the east and those in the west. Interestingly, two clusters distinguish between northeast fluted and Clovis/Folsom sites. Equally intriguing is a cluster composed of Clovis and Folsom. Clustering has to be taken all the way down to the eighth level before kills are distinguished from kill site/camps.

Even with all the data limitations, cluster analysis seems to be a useful exercise. This analysis did not allocate sites into different fluted point traditions, perhaps because we did not use detailed technological or metric attributes. The next step, beyond the scope of this study, would to be to apply this approach to post–fluted point Paleo-Indian assemblages and see whether they differ from fluted point traditions. We would also like to see this analysis greatly expanded by adding sites and refining the tool categories, as well as subcategories of bifaces and points that account for fragmentation, break causes, stage of use/reuse, and the like.

BERINGIAN AND WESTERN EUROPEAN SITE COMPARISON

Our analyses for stone tool assemblages and technological traits are shown in tables A.2 and A.3.

TABLE A.2 Tool Types, by Archaeological Culture, Compared in Cluster Analysis

Artifact type	Pre-Clovis	Fluted point tradition	Early French Solutrean	Middle French Solutrean	Late French Solutrean	North Spanish Solutrean	Nenana	Mesa/ Sluiceway	Ushki / Early Dyuktai
Bipointed point	0	0	0	1	1	0	0	1	1
Indented base point	1	1	0	1	1	1	0	0	0
Shouldered point	0	0	0	0	1	1	0	0	0
Willow leaf point	0	0	0	0	1	0	0	0	0
Stemmed point	0	0	0	0	1	0	0	0	1
Plane face point	0	0	1	1	0	0	0	0	0
Thin flake point	0	0	0	0	0	0	1	0	1
Biface knife	1	1	0	1	1	1	1	1	1
Side scraper	1	1	1	1	1	1	1	1	1
End scraper on blade	1	1	1	1	1	0	0	0	0
End scraper on flake	0	1	1	1	1	1	0	0	0
Spurred end scraper	0	1	0	1	1	1	0	0	0
Single graver	0	1	0	1	1	1	0	0	0
Multiple graver	0	1	0	1	1	0	0	0	0
Drill/borer	0	1	0	1	1	0	0	0	0
Burin	0	0	1	1	1	1	0	0	1
Limace	0	1	?	1	1	0	0	0	0
Adze	?	1	?	1	1	0	0	0	0

NOTE: 0 = absent; 1 = present.

* See Bradley, Collins, and Hemmings 2010 for a description of this tool form.

TABLE A.3 Technological Traits, by Archaeological Culture, Compared in Cluster Analysis

Technology	Pre-Clovis	Fluted point tradition	Early French Solutrean	Middle French Solutrean	Late French Solutrean	North Spanish Solutrean	Nenana	Mesa/ Sluiceway	Ushki / Early Dyuktai
Microblade	0	0	0	0	0	0	0	0	1
Bladelet	1	1	1	1	1	1	0	0	0
Large blade	1	1	1	1	1	1	0	0	0
Proportional biface	0	0	0	0	0	0	1	1	1
Thinned biface	1	1	0	1	1	1	0	0	0
Thickened biface	0	0	0	0	0	0	0	1	1
Overshot thinning	1	1	0	1	1	1	0	0	0
Diving thinning	0	1	0	1	1	0	0	0	0
Full-face thinning	1	1	0	1	1	0	0	0	1
Pressure edge retouch	1	1	1	1	1	1	1	1	1
Full facial pressure retouch	1	1	0	1	1	1	0	1	0
Fluting	0	1	0	0	0	0	0	0	0
Basal thinning	1	1	0	0	1	1	0	0	0
Fully bifacial precores	0	0	0	0	0	0	0	0	1
Flat-backed blade cores	0	1	0	1	1	1	0	0	0
Unidirectional blade cores	1	1	1	1	1	1	0	0	0
Edge grinding	1	1	0	1	1	1	0	1	0
Exotic material	0	1	0	1	1	1	0	0	0
Heat treatment	0	1	0	1	1	0	0	0	0
Isolated ground platforms	0	1	0	1	1	1	0	0	0

NOTE: 0 = absent; 1 = present

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NOTES

INTRODUCTION

1. Gemegah 1999.
2. Bolles 1999 discusses a poet (Elisha Kent), a professor (Louis Agassiz), and a politician-geologist (Charles Lyell) and "how their clash of egos, ignorance, and imaginations led to the discovery of the Ice Age."
3. Hrdlička 1923.
4. Meltzer 2006.
5. Wormington 1957.
6. Boldurian and Cotter 1999.
7. In this book we have had to deal with the thorny issue of reporting dates so that they are accessible to lay readers as well as archaeologists. We have chosen to report both radiocarbon dates and calendar dates whenever possible. Radiocarbon dating is done on organic remains recovered from sites, be it charcoal from a hearth or collagen from a bone. The date indicates the time of death of the living organism, based on the radioactive decay of carbon-14 that the organism acquired while alive, but it is expressed as radiocarbon years before present (RCYBP) and has a range depending on many factors, such as the purity of the sample and the ranges of individual readings within the sample. Although it was originally thought that the radiocarbon calendar would be the same as our calendar, the amount of radiocarbon in the atmosphere varies through time and therefore the derived dates cannot be used directly. There have been numerous studies that correlate radiocarbon dates with other means of dating, such as tree-ring, to yield absolute (calendar) dates and to derive calibration curves. We have chosen to use the OxCal calibration curve (the version current in September 2009) and have calibrated

our dates directly from the online calculator at http://c14.arch.ox.ac.uk/embed.php?File=oxcal.html.

Even with the calibration curve worked out there are further complications, because radiocarbon dates are always given with a range and standard deviation (e.g., 12,240±40). This indicates that the date could be anywhere between 12,280 and 12,000 RCYBP. So what is the calendar year? This would also be a range of dates. However, to simplify our reporting of calendar dates we have usually chosen to give the calibrated date based on the actual radiocarbon date, disregarding the standard deviation. Therefore the calendar dates we give should be considered approximations rather than absolutes: we frequently use calendar years as general statements, especially when carbon dates were not available (because the dates we have either are based on other approximations, such as geological dating, or extend beyond the calibration curves, which end around 21,000 RCYBP). Readers who want to deal with more explicit calibrations are encouraged to do their own research with the available calculators.

8. W. A. Johnston 1933.
9. Hayes 1991.
10. Thompson 1948. See Dixon 1993 for a complete review of Alaskan fluted points.
11. Solecki 1951.
12. Wormington and Forbis 1965.
13. Stanford 1983a.
14. Dyke, Moore, and Robertson 2003.
15. Fladmark 1978.
16. Bednarik 1997.
17. For an overview of the controversies about the first Americans, see the papers in Shutler 1983. For a recent update on these issues, see the papers in Bonnichsen et al. 2005.
18. Jelinek 1965.
19. Frison and Bradley 1982.
20. Greenman 1963.
21. The earthly remains of an individual now known as Kennewick Man for a nearby town or as the Ancient One to Native Americans, were found by two students along the bank of the Columbia River in Washington State. The preliminary coroner's inquest noted that his skull was shaped significantly differently from those of modern Native Americans and looked more like that of a European. Therefore, it was concluded that he was of European descent, although the weathered condition of his bones implied that he was not a recent casualty but perhaps a nineteenth-century trapper or settler. When a stone weapon tip known to be thousands of years old was found embedded in his hip bone, it was clear that the story of Kennewick Man was more complex and that he would provide important clues to the deep prehistory of the Columbia River Basin. A radiocarbon assay made from a sample taken from one of his finger bones suggested that Kennewick Man lived around 9,500 years ago, sending newspaper reporters into a virtual feeding frenzy, with some of them proclaiming that ancient Europeans discovered the Americas. The popular articles were of course inflammatory, and angry Native Americans clamored for the immediate reburial of the Ancient One.

The remains of several other individuals from different sites of roughly the same antiquity have been studied since the discovery of Kennewick Man, and they all fall into the same general physical type. The so-called Caucasoid features upon which the original assessment of

Kennewick Man was made are indeed characteristic of Europeans today; however, these were common physical traits in early prehistoric populations in the Northern Hemisphere and are even retained by some modern south Asians. The apparent dominance of these physical features at an early date in America implies that the peopling of the New World occurred when early modern humans were first spreading throughout the world. It was only after the north Asian physical type developed that tribes dominating the ancestry of modern Native Americans moved into the Americas and intermingled with the pre-existing populations that they met along the way. For additional details, see Chatters 2001 and Benedict 2003.

22. There are two forms of DNA, one found in the cell nucleus and one which occurs in the cytoplasm surrounding the nucleus. The latter, termed mitochondrial DNA or mtDNA, is known as the "Eve gene" because it can be used to trace human heritage through time, presumably all the way back to Eve. This is possible because mtDNA is present in the maternal egg cell. Researchers have determined that mtDNA occurs in only a few dozen general patterns, which are called haplogroups. These groups have been assigned letter identifiers, and each one is believed to comprise the descendants of a single prehistoric female. A new haplogroup forms when a mutation occurs, which happens at the rate of 2.2–2.9 percent over a million years. The spread of related female lineages can be traced through the identification of mtDNA haplogroups and their distributions across the landscape. For instance, preliminary research indicated that most Native Americans could be traced back to four Asian haplogroups (A, B, C, and D), while Europeans find that they are descendants of nine haplogroups (I, J, and K, thought to be the original Paleolithic peoples, were followed by H, T, U, V, W, and X). But mitochondrial haplogroup X also occurs in North American populations more than 9,000 years old (see Smith et al. 2002) and in modern Native Americans (see Brown et al. 1998 and Schurr 2000), pointing to an ancient link between western Eurasia and North America. Apparently, mtDNA X originated in North Africa and spread into Europe and into North America sometime between 13,000 and 34,000 years ago, long before Clovis. An important bit of information from our point of view is that the easternmost occurrence of the X haplogroup is in the Altai region of south Siberia. If the ancestors of the Native Americans who carry the X marker and their clans traversed Siberia on their way to America, they did so without leaving any genetic markers behind. This is unlikely human behavior.

Lepper 2009 suggests that the occurrence of mtDNA X, along with other North American haplogroups, in a small percentage of the Altai region population makes its appearance in the Americas less of a mystery. Before we consider this conclusion a fact, we must understand how X was transmitted from western Europe and why it does not occur in eastern Asia. Note that the Altai region is farther from Nome, Alaska, than from Paris. Another curious bit of information is that X is most common in tribes from the St. Lawrence Basin of eastern North America, becomes increasingly rare to the west, and is totally absent from the Arctic and sub-Arctic regions of North America (and Asia), a pattern that is similar to the distribution of Clovis artifacts. The relationship between mtDNA haplogroup X and either Clovis or Solutrean people is unknown at this time, as no human remains associated with either tradition have been tested, but we hope future research will resolve these issues.

23. Flemming 2004.

24. Kirch 2000 presents an excellent overview of the early evidence of boat travels in the Pacific. Strasser et al. 2010 discusses data from twenty-eight pre-ceramic lithic sites found on

Crete. These sites have been dated by their geologic context to be at least 130,000 years old. Because Crete has been separated from the mainland for millions of years, the presence of these sites indicates "open-sea navigation and multiple journeys and pushes seafaring in the Mediterranean back more than 100,000 years" (145–90). It will be interesting to follow further research here: if this conclusion is correct, it could have major implications for the dispersal of modern humans.

1. FLAKED STONE TECHNOLOGY

1. See, e.g., Cotterell, Kamminga, and Dickson 1985.
2. Speth 1974.
3. Whittaker 2004.
4. Speth 1972, 1974.
5. Whittaker 1994.
6. Bradley 1982.
7. For an example of hand ax technology, see Bradley and Sampson 1986.
8. Bordes 1961.
9. Bradley and Giria 1996.
10. Collins and Lohse 2004.
11. Goebel 2004.
12. Bradley and Stanford 1987.
13. Ingbar and Frison 1987.
14. Jodry 1998.
15. Solutrean: Aubry, Nevis, and Walter 2003; Clovis: Bradley, Collins, and Hemmings 2010.
16. Kelterborn 1984.
17. Sinclair 1995.
18. For an example of controlled overshot flaking that is unlikely to be historically related to either Solutrean or Clovis, see Inizan and Tixier 1978.
19. For a description of one possible fluting method, see Gryba 1988.

2. CLOVIS

1. Waters and Stafford 2007.
2. After the Last Glacial Maximum, between 25,000 and 13,000 years ago, the climate warmed and stabilized. This episode is known as the Bølling interstadial. It lasted from 14,700 to 12,700 years ago and preceded an unstable period whose climate shifted between warmer and cooler conditions. This ended with an abrupt plummet into a long-term cold, dry, and windy episode known as the Younger Dryas, from 12,800 to 11,500 years ago, which returned the environment to ice age conditions.
3. Bonnichsen and Will 1984.
4. E. Callahan, personal communication, 1999. See also Gardner 1974.
5. Collins, personal communication, January 2011.
6. Collins et al. 1989.
7. Broster and Norton 1993.

8. Mason 1962. At the time of Mason's publication, reviewers cited the lack of both supporting radiocarbon dates and evidence of a progenitor of fluted point technology as reasons to consider his suggestion premature at best.

9. Brennan 1982.

10. Lepper 1983.

11. Renaud 1934. See also Figgens 1934; Cotter 1935.

12. There are a limited number of other possible variants, but none of these has been well dated or found in stratigraphic relationship to Clovis.

13. Carson-Conn-Short: Broster and Norton 1993; Williamson: McCary 1951; Adams: T. N. Sanders 1990; Sinclair: J. Broster, personal communication, 2009; Pine Tree and Topper: Goodyear and Steffy 2003.

14. Frison and Todd 1986.

15. D. G. Anderson and Gillam 2000.

16. Blades: Greene 1963; points: Stanford and Jodry 1988; mixes: see, e.g., Frison and Bradley 1999.

17. Meltzer 2002.

18. The McInnis Cache, found south of St. Louis, Missouri, comprises eleven bifaces, nine blades, and a broken Clovis point made of Burlington chert. Another Clovis-style biface made of Burlington chert was found on the Columbia River just below the Grand Coulee Dam in the 1950s by Erma Pryor. Mrs. Pryor gave this specimen to Marilyn Palmer. Subsequently, Mrs. Palmer gave the specimen to Peggy Carnes, who along with her daughter, Kelly Carnes, donated it to the Smithsonian. All of these specimens are housed at the Smithsonian Institution in Washington, D.C. Although out of context, the Burlington chert biface was probably made near St. Louis and probably carried in an unmodified condition to a location on the Columbia River. Its likely route of travel was up the Missouri River into western Montana and across the Lolo Trail into the Columbia River Basin. Perhaps a party of Clovis people pioneered the trail that Sacagawea led Lewis and Clark along 13,000 years later: the original voyage of discovery.

19. The reliability of radiocarbon dating is again under scrutiny, and the current debate, based on new data, indicates that it is very difficult to interpret and should be used with caution. This is especially true for dates between 11,000 and 15,000 years ago derived from non-archaeological sources, where scientists have discovered great inconsistency.

20. Charlie Lake Cave: Fladmark, Driver, and Alexander 1988; Alaska: Bob Gal, National Park Service archaeologist for Northwest Alaska, personal communication, 2009.

21. C. V. Haynes Jr. et al. 1999.

22. T. A. Morrow and J. E. Morrow 1994.

23. Frison and Bradley 1999.

24. Beck and Jones 1997.

25. Adair-Steadman: Tunnell 1977; Lindenmeier: Wilmsen and Roberts 1978; Hanson: Frison and Bradley 1980.

26. C. V. Haynes Jr. and Huckell 2007.

27. Bement and Carter 2003.

28. G. Haynes and Stanford 1984.

29. A new date from the bone indicates that it was of Clovis age and not related to the later bison kill. See Bement and Carter 2010.

30. McNett 1985.
31. Ferring 2001.
32. Stanford 1983b.
33. Collins et al. 1989.
34. Collins 2002.
35. A Clovis point that retains significant portions of the flake blank surface was included in the Anzick Cache in Montana, and at least four were encountered at Blackwater Draw. Most appear to have been made on thin flakes. The reduced surface is the dorsal side of the flake or blade, and the less modified surface is the ventral side. Pressure flaking to flatten the bulb of percussion and minor edge retouch from shaping are the only modifications on the ventral faces. The dorsal surfaces were finished with the same steps and techniques used to produce a bifacial specimen.
36. Wilke, Flenniken, and Ozburn 1991.
37. To develop a comparative sample for the presence of controlled overshot flake scars on non-Clovis bifaces, we examined 418 bifaces from Archaic and Late Prehistoric contexts at the Gault site. These and the underlying Clovis bifaces were produced in the same location, and the knappers had access to the same sources of high-quality flint. Any differences between technologies cannot be explained by raw material availability. We studied bifaces recovered by Prof. J. E. Pearce during excavations in 1929 (see Pearce 1932). The vast majority of these were unfinished, but we did not include fragments. We classified overshot flake scars as: error (the flake removal resulted in the termination of production), unknown effect of overshot flake removal (did not harm the biface), and possibly intentional. Although the artifacts were recovered from post-Clovis deposits, there is the possibility that some were actually Clovis in origin and were mixed into the later deposits in a number of ways (the excavations were done with shovels, and mixing of strata was frequent). Two of the bifaces we examined look to have been Clovis based on a suite of technological traits, including controlled overshot flaking, and a distinctive yellow patina seen on many Clovis artifacts. Nevertheless we included these in our sample. Out of a total of 418 bifaces, 409 (98 percent) did not have overshot flake scars and 9 (2 percent) had them. Of these 9, 3 were abandoned because of overshot failure, 1 had what looked like an intentional overshot, and 5 had overshot scars that did not result in abandonment but also were not evidently intentional (most were at the tip or base of the biface). All told, overshot flaking at Gault in post-Clovis technologies is extremely rare and does not represent an intentional part of any of the biface technologies extending from Late Paleo-Indian through Late Prehistoric times.
38. Bradley 1997.
39. This possibility is even greater in the Folsom fluting method, which demands even more expertise and has higher failure rates. For other evidence that Folsom fluting may have taken on a ritual function, see Bradley 1982.
40. Collins 2002.
41. Broster and Norton 1993.
42. For more information, see Bradley, Collins, and Hemmings 2010, 10–55.
43. End scrapers are tools that have been retouched on the end of a flake or blade. Although they are called *scrapers,* microscopic analysis of use traces has indicated that this tool type had

multiple uses—generally for preparing animal skins for rawhide or leather but sometimes for working wood and other more durable materials such as bone and antler.

44. Shoberg 2010. The butchering reference is in figure 6.4, p. 143.

45. Tomenchuk and Storck 1997.

46. Wilke, Flenniken, and Ozburn 1991.

47. Nami et al. 1997.

48. Hemmings, Dunbar, and Webb 2004.

49. Hannus 1997.

50. Gramly 1993. The East Wenatchee Cache is also known as Richey-Roberts.

51. Lahren and Bonnichsen 1974.

52. Owsley and Hunt 2001. There are some real problems with these two skeletons relative to their association with the Clovis Cache. The bone foreshafts have a good, solid Clovis age radiocarbon date of 11,040±35 RCYBP. The toddler has a date of 10,680±50 RCYBP, while the other child has a date of 8,600±90 RCYBP. The toddler's bones are covered with red ocher, but the other child's remains are not stained. Unfortunately, the entire site, including the artifacts and remains, was disturbed by earthmoving equipment, and the exact locations of the burials relative to the cache are unknown. It may be that they were not associated with the Clovis Cache but were incidentally buried nearby and the red ocher staining the toddler's bones is purely coincidental.

53. Recent studies indicate that these items were made from elk antler rather than bone; see J. Morrow and Fiedel 2004.

54. Lahren and Bonnichsen 1974.

55. Stanford 1997.

56. C. V. Haynes Jr. and Huckell 2007.

57. C. V. Haynes Jr. and Hemmings 1968.

58. Boldurian and Cotter 1999.

59. While at Point Barrow, Alaska, between 1881 and 1883, J. Murdock, an ethnologist from the Bureau of American Ethnology, collected thirteen hafted mauls and thirteen flaking hammerheads. Murdock 1892 shows a small hammer with a bone head. This hammerhead is undamaged, but others in the collection and hammers used in flintknapping experiments are broken in the manner of the Blackwater Draw specimen.

60. Saunders et al. 1990.

61. The rod was originally identified as ivory, in Frison and Stanford 1982. The analysis in the supporting material for Waters and Stafford 2007 determined that the artifact is made of either bone or antler.

62. S. D. Webb 2006.

63. Dunbar 1991.

64. Wilmeth 1968.

65. Cressman 1946.

66. Tankersley 1997.

67. Hemmings 2004.

68. Stanford, Bonnichsen, and Morlan 1981.

69. Hannus 1989.

70. Bradley 1995.
71. Hester 1972.
72. Collins et al. 1991.
73. Rawls 2009.

3. BERINGIA

1. Hopkins et al. 1982.
2. W. A. Johnston 1933.
3. Mandryk et al. 2001.
4. West 1996.
5. Hopkins et al. 1982.
6. See Colinvaux 1981; Colinvaux 1996.
7. Elias et al. 1996.
8. World Wildlife Fund 2008.
9. With minor reservations, we concur with the interpretations summarized in West 1996. Where we part company is in the interpretation of the existing Arctic data relative to the origin of Clovis culture. See also West 1981.
10. See, e.g., Abramova 1984; Kashin 1991.
11. Pitulko et al. 2004.
12. Although edge grinding is unreported in Siberian assemblages, a putative fluted point from the Uptar Site in northeastern Siberia, dating to less than 9,000 years, has heavy basal grinding. The point is not fluted but instead has an impact scar. When inverted 180 degrees, it fits into the same bi-pointed projectile type as was found at the site. See King and Slobodin 1996.
13. Derev'anko 1998.
14. Goebel, Waters, and Dikova 2003.
15. Dikov 1996; Powers 1973.
16. Mochanov and Fedoseeva 1996.
17. Vereshchagin and Ukraintseva 1985.
18. See Vartanyan 1995; Vartanyan, Garutt, and Sher 1993.
19. Vereshchagin and Ukraintseva 1985.
20. Hoffecker, Powers, and Goebel 1993.
21. D. D. Anderson 1970.
22. Odess and Rasic 2007.
23. Crass and Holmes 2004.
24. West 1996.
25. Larson 1968.
26. Humphrey 1966.
27. Alexander 1987. For additional information on the dating of fluted points in Alaska, see Kuntz and Reanier 1994; Dixon 1999.
28. Hamilton and Porter 1975.
29. Kuntz and Reanier 1995.
30. See, e.g., Dixon 1999.
31. Ted Goebel and Kelly Graff, personal communication, November 2010.

32. Gryba 1988.
33. Fladmark, Driver, and Alexander 1988.
34. Kuntz, Bever, and Adkins 2003.
35. Kuntz and Reanier 1994.
36. Hamilton and Goebel 1999.
37. Justice 2002.
38. Lohse and Sammons 1994.
39. The Sluiceway Site was found and tested by Bob Gal and Tom Hamilton in 1992 and later excavated by Dennis Stanford in 1994 and 1998. During the summer of 1998 a large Sluiceway manufacturing site was found by Jeff Rasic on Tuluaq Hill in the Western Brooks Range, and subsequent surveys in the area and examination of collections produced thirty-four sites with Sluiceway artifacts. See Rasic 2008.
40. See Rasic 2008.
41. Hamilton and Goebel 1999.
42. Cook 1996.
43. See Goebel, Powers, and Biegelow 1991; Holmes 1996; Holmes, VanderHoek, and Dilley 1996.
44. Crass and Holmes 2004.

4. CHALLENGING THE CLOVIS FIRST MODEL

1. Fitzhugh 2001.
2. Not all technologies develop successfully to deal with new situations, and sometimes they transform for unknown reasons. Henrich 2004 examines the change in technology in Tasmania, which has resulted in a continual loss of knowledge, and finds no environmental or adaptational explanation.
3. There is a lengthy history of archaeological research seeking to find "pre-Clovis" in the Americas. See Dixon 1999 for a comprehensive review of these research projects and a critical appraisal of the North American sites considered older than Clovis.
4. For example, we do not include the evidence of an early occupation at the Monte Verde site in Chile, as we do not see a connection between the technology used there and the development of Clovis in North America. We contend that the paleolithic people of Monte Verde had a completely different ancestral heritage, stemming from a population from another place and time than the ancestors of Clovis people.
5. Adovasio and Page 1997. Everything in the text about Adovasio is from here.
6. Although some scholars have argued that the stratum IIa charcoal samples were contaminated by coal particulate or soluble material incorporated into the groundwater to explain their unexpected antiquity, a detailed independent study of the microstratigraphy found no evidence of either contamination or fluctuating groundwater levels and concluded that the early dates are probably as accurate as the later ones. See Goldberg and Arpin 1997.
7. Boldurian 1985.
8. Another argument against the earliest Meadowcroft dates is that the plant and animal remains in the lower levels are all from species adapted to modern woodlands rather than a late Pleistocene environment. However, this incongruity does not invalidate the radiocarbon re-

sults. The sample of organic remains from these levels was extremely small. Only eleven animal bones could be identified, from a white-tailed deer, southern flying squirrel, deer mouse, passenger pigeon, snake, and toad. While these animals are indeed characteristic of the Carolinian biotic province (basically a modern habitat; for an excellent discussion, see Colthurst and Waldron 1993), they have broad ecological tolerances and have been found throughout the Carolinian and Canadian biotic ecotone (the boundary of two or more major ecological zones) and in equally old paleontological records farther north, in the Upper Ohio Valley. In fact, animals such as the white-tailed deer are extremely adaptable and thrive in a wide variety of environmental niches, making the significance of their presence ambiguous. J. E. Guilday and P. W. Parmalee, the archaeozoologists who analyzed the Meadowcroft fauna and fauna from many other sites of similar antiquity in the eastern United States, suggest that the period of transition between the ice age and modern environments may have taken place during a relatively short time in western Pennsylvania (see Guilday and Parmalee 1984). Such rapid habitat shifts can be observed today. For instance, the current warming of our climate has pushed the Baltimore oriole northward sufficiently that its range no longer includes Baltimore, and ravens have replaced it as the Baltimore totem animal. Similarly, robins previously unknown above the Arctic Circle have recently begun to delight the Inuit children at Point Barrow, Alaska, by heralding the onset of summer.

The plant remains indicate that a mixed conifer-hardwood forest dominated by oak, hickory, pine, and walnut trees and with a hackberry understory surrounded Meadowcroft. While these species argue against a boreal or tundra environment, they are compatible with a mosaic or patch environment rather than a uniform periglacial one. This interpretation is supported by Meadowcroft's low elevation and southern exposure, whose milder ambient temperatures would have allowed earlier colonization by some woodland life forms. Further, the plant and animal associations during the last ice age were "disharmonious" by today's standards, combining, for example, patches of tundra, woodland, and boreal communities of the kind represented in the Meadowcroft area at the time of the earliest occupations of the shelter.

9. McAvoy and McAvoy 1997.
10. Wagner and McAvoy 1997, 2004.
11. See McWeeney 1997, 2000.
12. Collins 1999.
13. M. F. Johnson 1997.
14. See Lowery 2007; Lowery et al. 2010.
15. Wah 2003.
16. R. C. L. Wilson, Drury, and Chapman 2000 has an excellent summary of the geologic and environmental processes at the end of the LGM.
17. Lowery et al. 2010. Tilghman Island is the namesake of the paleosol, which Lowery named.
18. Lowery 2008.
19. Hobbs 2004.
20. Specialized studies of the Cinmar site include a radiocarbon assay by Tom Stafford of Stafford Research, Inc., Lafayette, Colorado; use-wear studies by Marvin Kay of the Department of Anthropology, University of Arkansas, Fayetteville; a search for the source of the projection point's rhyolite by Jeff Speakman of the National Museum of Natural History, Smith-

sonian Institution; and lithic analysis by Bruce Bradley of the Department of Archaeology, University of Exeter.

21. See Stewart 1987; Bondar 2001. For further reading on eastern meta-rhyolites, see Stewart 1984.
22. Shea 1999. See also Grosman et al. 2011.
23. Hallin 1983.
24. Faure, Walter, and Grant 2002.
25. Weaver et al. 2003.
26. Lowery et al. 2010.
27. J. D. Webb 2006.
28. Dunbar and Hemmings 2004.
29. Redder 1985.
30. Daniel and Wisenbaker 1987.
31. Dunbar et al. 2005.
32. Hemmings 2004.
33. Baker and Broster 1996.
34. See Waters and Stafford 2007. Several years after the first dates were obtained from the hearth features, an attempt was made to validate the original results. New charcoal was collected from the cut bank and assayed to circa 9,000 years old. But there is a 9,000-year-old occupation level above the proto-Clovis level, and since the cut bank had eroded since the first assay, the charcoal collected on the second dating attempt was probably either from the wrong level or redeposited down the bank by surface erosion. Whatever the cause of the younger date, it is clear that the artifacts recovered from the lower level are technologically much older than the 9,000 years level, and there is little reason to disregard the dates from the original assay.
35. Adovasio and Page 1997.
36. Overstreet 2004.
37. Overstreet et al. 1997.
38. Overstreet 2004.
39. Arnold 2002.
40. Turner et al. 1997.
41. Mill Iron: Frison 1996; Jim Pitts: Donohue and Sellet 2001.
42. M. C. Wilson and Burns 1999, 235.

5. THE SOLUTREAN

1. Jelinek 1965.
2. See, e.g., Churchill and Smith 2000.
3. For a comprehensive discussion of the Aurignacian, see Bar-Yosef and Zilhão 2006.
4. Pettitt 2008.
5. See Sandars 1968.
6. The traditions in Portugal and Mediterranean Spain share general biface and blade technology, shouldered points, and other artifact forms, such as laurel leafs and end scrapers, with

the northern Solutrean. They share other characteristics, such as arrow points, with some North African technologies, which Otte 2002 sees as evidence of Solutrean origin.

7. Pettitt et al. 2003.
8. P. E. L. Smith 1966.
9. See, e.g., Aubry et al. 1998.
10. See, e.g., Straus and Clark 1986.
11. Hogg and Johns 1995.
12. Rigaud and Simek 1990.
13. Sackett 1981.
14. Combier and Montet-White 2002.
15. Walter and Aubry 2001.
16. P. E. L. Smith 1966.
17. Rigaud and Simek 1990.
18. Straus 1986.
19. Clottes and Courtin 1996.
20. Straus and Clark 1986.
21. Bird 2002.
22. See, e.g., Butzer 1986.
23. Adovasio, Soffer, and Kléma 1996.
24. Adovasio, personal communication, 2001.
25. Straus 1992.
26. Pokines and Krupa 1997.
27. Chadelle, Geneste, and Plisson 1991.
28. Straus reports that of the nineteen concave base points found at La Riera Cave, eighteen were from levels 4–7 and the other was out of context. Straus and Clark 1986.
29. P. E. L. Smith 1966. See especially figure 74–13.
30. Sinclair 1995.
31. Bordes, personal communication, 1969; Collins 1973; Tiffagom 2006.
32. Collins insisted it was necessary to show a pattern of heat alteration that occurred during the manufacturing process, after initial flaking and before final flaking, as indicated by differences in luster of adjacent flake scars.
33. Whittaker 1994. Modern knappers frequently use French boxwood billets for striking blades, but it is unlikely that these would have been available to Solutrean knappers.
34. Aubry et al. 2003.
35. To be counted as exhibiting overshot flaking the biface must have had at least one overshot flake scar that removed part of the edge opposite the platform. Many pieces exhibited more than one such scar.
36. Pelegrin 1990.
37. Clottes and Courtin 1996.
38. Toggling harpoons have detachable points tied to a line that either attaches to a float or can be held by hand. When the harpoon penetrates the animal, the shaft detaches, leaving the point inside. Force on the attached line turns the harpoon point sideways, greatly increasing its attachment to the animal. These points were designed to stay in. While this design is superior to that of other points used to procure sea mammals (if a line isn't attached, many an-

imals are lost when they sink in deep water), other forms have been used successfully, such as the self-barbed spear point. There are also cases where toggling harpoons were used to hunt terrestrial animals.

39. Garcia 1927.
40. P. E. L. Smith 1966; Rigaud and Simek 1990.
41. Bradley, Anikovitch, and Girya 1995.
42. Garrod 1926.
43. Otte 2002.
44. Strasser et al. 2010.

6. QUANTITATIVE CULTURE COMPARISON

1. Toth and Schick 2005.
2. Amvrosievka: Krotova and Belan 1993; Horner: Frison and Todd 1987.
3. D. H. Thomas 1998.
4. See, e.g., Bordes 1972; Movius 1975; Leroi-Gourhan 1957; Straus and Clark 1986; Aubry et al. 2003; Combier and Montet-White 2002.
5. J. M. Adovasio, personal communication, 2007.
6. By *generalized* we mean reconstructed through the study and analysis of a large number of individual pieces. This sequence is sometimes called the production strategy, and by the French *chaîne opératoire*. Especially helpful in these reconstructions are pieces on which we are able to refit the flakes and thus see the sequence of individual choices. These are rare, however, so we often have to rely on reconstructions based on pieces that were abandoned during the flaking process, frequently fragments.
7. We have used *early, middle,* and *late phase* to describe Clovis and Solutrean biface reduction, but not all biface technologies can be readily subdivided in this way. Therefore for this analysis we have opted for the terms *primary* and *secondary flaking*. Generally, the early and middle stages fit with primary and the late stage with secondary flaking. While we have attempted to use observations that archaeologists would generally agree on, there could certainly be alternative interpretations of specific attributes.

   The characteristics selected for use in this analytical approach vary depending on the technologies being compared. For example, the comparison of blade technologies does not include such traits as thinning and finishing. Ideally, the characteristics of a technology are determined through rigorous peer review; although DSA has not undergone this process (yet), we feel it is useful and should be further developed.
8. See Bradley, Collins, and Hemmings 2010 for specific examples and definitions of these technical terms.
9. For the Solutrean: Collins 1973; for Clovis: Wilke, Flenniken, and Ozburn 1991.

7. QUALITATIVE CULTURE COMPARISON

1. Demars and Laurent 1992: 40–41, figure 63 *("micrograttoir de Laugerie-Haute")*. These scrapers also appear in the Grimaldi Magdalenian and become common in the Azilian and other Epipaleolithic assemblages.

2. Clovis: Collins 1999; Eurasian Upper Paleolithic: see, e.g., Giria and Bradley 1998.
3. Clovis and Solutrean peoples produced bladelets and larger blades from the same core types, whereas Asian microblades were produced from a variety of specially prepared wedge-shaped microblade cores.
4. Bradley, Collins, and Hemmings 2010.
5. Tunnell 1978; see also Collins 1999.
6. Bradley, Collins, and Hemmings 2010.
7. Lowery and Stanford 2008.
8. Wilke, Flenniken, and Ozburn 1991. However, the appropriately strict criteria developed by Mike Collins to confirm heat treatment were not applied. See Collins 1973.
9. Stanford 1997.
10. Hemmings 2004.
11. Hemmings, Dunbar, and Webb 2004.
12. Picat 2009.
13. Guthrie 2005; Villaverde Bonilla 1994 is an excellent two-volume analysis and illustration of the art of Parpallo Cave.
14. Excavations in South Africa have revealed extensive bead use and manufacture in 70,000-year-old deposits in Blombos Cave. See Bouzouggar et al. 2007. While very early compared to Eurasia, this is nevertheless likely the work of modern humans rather than an earlier hominid form.
15. Stone pendants have been recovered from the Uptar Site in western Beringia, but their association with early dates is questionable at best. See King and Slobodin 1996.
16. Amick, Hoffman, and Rose 1989.
17. Kilby 2008.
18. Mochanov and Fedoseeva 1996.
19. D. D. Anderson 1970.
20. These floors are just post-Solutrean in time, and there was a minor Solutrean use of the site, but the associated artifacts are Magdalenian.
21. See chapter 6 in Bradley, Collins, and Hemmings 2010.
22. Straus et al. 1980.
23. Owsley and Hunt 2001.
24. Straus 1990. Straus 1977 points out that concave (indented) base points are restricted in distribution to a narrow (circa 25 kilometer) coastal zone of northern Spain near the Cantabrian Sea (Bay of Biscay) and the French border. Smith 1966 suggests that concave points might have been used for hunting specific game. Alternatively, Straus 1977 hypothesizes that they might have had social or territorial connotations. We agree that both situations may have been in play, but we suggest that the concave base points show up in this narrow coastal zone due to its proximity to the coast and that they were fashioned for harpoon-related gear. These points do not appear in Solutrean sites in the interior of Spain or France; moreover, at La Riera Cave they are restricted to the levels that contain the majority of fish and shellfish remains. Thus, we think coastal-adapted people may have seasonally used the uplands for hunting, while other Solutrean groups used the cave for their activities and employed different types of hunting gear armed with shouldered points.

25. Straus and Clark 1986.
26. Frison and Bradley 1980.
27. Straus, Meltzer, and Goebel 2005 presents a compilation of Beringian-Siberian Paleolithic typological and technological traits intended to show that traits we think link Clovis and the Solutrean are also found in Siberian Paleolithic cultures, thereby negating our hypothesis. Among the problems with their comparison is that they include middle through late Upper Paleolithic sites from an immense area stretching from southwestern central Siberia through central Alaska, and by including the Yana Site and Culture Zone 3 at Broken Mammoth they borrow from a span of 17,700 years. What couldn't one find in such an immense area through such a huge time range? By contrast, we are comparing well-defined technologies from two restricted areas: the Solutrean from southwestern France and the area of Spain north of the Cantabrian Range, and the Mid-Atlantic pre-Clovis through Clovis. For additional discussion of Straus, Meltzer, and Goebel's evaluation of the Solutrean hypothesis, see Bradley and Stanford 2006.
28. G. Haynes 2002.
29. We concur with Straus, Meltzer, and Goebel 2005 about what we should find in pre-Clovis assemblages. Although the pre-Clovis record in eastern North America is still sparse, the artifacts that have been found do meet these expectations. The Beringian record does not.

8. THE SOLUTREAN MARITIME ADAPTATION

1. Straus and Clark 1986.
2. Ibid., 350–65.
3. Binford 2001.
4. Altuna 1986.
5. Freeman 1973 estimates the average weights of usable meat from various species of animals hunted by the Paleolithic peoples of northern Spain.
6. Binford 2001.
7. Pokines and Krupa 1997.
8. Ortea 1986.
9. Binford 2001, table 7.13.
10. Butzer 1986.
11. Straus and Clark 1986, 367–83.
12. Mol et al. 2008.
13. Lowery 2001.
14. Erlandson 2001.
15. Straus and Clark 1986, 350–65.
16. Cleyet-Merle 1990.
17. Straus 1990.
18. Straus 1977 suggests that the variation in projectile point types might reflect either seasonal or functional use of different hunting gear or the use of different point types by different Solutrean groups.
19. Straus 1990.
20. Lyman, Clark, and Ross 1988.

9. THE LAST GLACIAL MAXIMUM

1. CLIMAP 1976.
2. COHMAP 1988.
3. Mix, Bard, and Schneider 2001.
4. For an in-depth but readable discussion of the issues of understanding the ice age physical environment, see R. C. Wilson, Drury, and Chapman 2000.
5. Robinson, Maslin, and McCave 1995.
6. The amount of ^{18}O incorporated in the organism's shell increases relative to the amount of ^{16}O as the water gets colder. A 1°C drop in sea surface temperature results in an increase of 0.2‰ in the $\delta^{18}O$.
7. Late Proterozoic, between about 600 and 800 million years ago; during the Pennsylvanian and Permian, between about 250 and 350 million years ago; and the late Neogene to Quaternary, the past 4 million years.
8. Bond et al. 1993.
9. Heinrich 1988. See Alley 2000 for an informative discussion of Heinrich and Bond events.
10. Dansgaard et al. 1993.
11. Dyke et al. 2002.
12. Bowen et al. 2002.
13. Bellamy 1995.
14. Butzer 1986.
15. Straus, Bicho, and Winegardner 2000.
16. For the latest summary of the results of excavations at Solutré, see Combier and Montet-White 2002.
17. Rigaud and Simek 1990.
18. Ortea 1986.
19. Altuna 1986.
20. Reeves et al. 2002.
21. Clark 1946. Due to sea level rise there is little direct evidence of seal hunting in Europe before the later Paleolithic period.
22. "Recent ethnoarchaeological work among coastal foragers in Torres Strait indicates that for reasons of transport efficiency fish and especially shellfish are likely to be processed close to shore, and that (depending on processing costs) few elements susceptible to archaeological preservation will be moved more than a kilometre or so off the beach," Bird 2002.
23. O'Connor and Veth 2000.
24. Butzer 1986.
25. Ibid.
26. Miller et al. 2002.
27. Dyke, Moore, and Robertson 2003.
28. Prest 1984.
29. Dyke et al. 2002.
30. There is an unconfirmed recent report that a mammoth tusk was dredged up from the Grand Banks. If verified, this would mean that the Grand Banks sustained plant and animal

life. The environment would have been much like that of modern-day Baffin Island but with lusher vegetation thanks to the prolonged sunlight of its lower latitude.

31. See J. E. Sanders 1962; Shepard 1963.

32. Richards and Judson 1965.

33. Curray 1965.

34. Bumpas and Peirce 1955.

35. Dyke et al. 1999.

36. Milliman, Pilkey, and Ross 1972.

37. L. J. Jackson et al. 2000.

38. See Bothner and Spiker 1980; Emery et al. 1967.

39. S. T. Jackson et al. 1997.

40. Lowery 2002.

41. Whitmore et al. 1967.

42. Hemmings 2004.

43. Westley and Dix 2008.

44. Perennial ice cover: Falkowski and Raven 1997; freeze-thaw of ice pack: D. L. Wilson, Smith, and Nelson 1986.

45. De Vernal and Hillaire-Marcel 2000.

46. T. Webb et al. 1996. We generally agree with this study's findings, but in our opinion there are problems with the interpretations made from similar studies. We are looking for the edge or maximum extent of permanent ice, which would sometimes shift rapidly and at other times might be stationary for hundreds of years. This is a process rather than an event, and the difficulty of mapping a dynamic process likely accounts for the wide variation in interpretations of the location of the ice edge. During warming phases, as seen in the Greenland ice core, the ice edge retreated north, and during colder periods it extended south. Perhaps the maps do represent the very maximum extent of the LGM ice, but to accept that would mean presuming that the organisms found in deep-sea cores lived at the same spot were the core was taken, and there is little discussion in the paleoceanogaphic literature about taphonomic processes—how things such as dead organisms, bones, etc., become deposited in the sediments where they are found. It seems unlikely to us that these tiny organisms represent the sea surface conditions directly above the core; more probably, they were deposited down-current from their point of origin. This would skew the results in the North Atlantic by overrepresenting organisms that dwell in warmer water whose remains were carried north and east by the Gulf Current: it would look like the ice edge was farther north than its real location.

47. Productivity estimates are based on the presence of hard-bodied organisms in the sediments on the sea floor. Unfortunately, there is no way to determine the variety and number of soft-bodied creatures that were well adapted to extreme cold temperatures. For instance, scientists have only recently discovered several hundred heretofore unknown cold-adapted species, both hard- and soft-bodied, in both polar seas (Casey 2009). In part based on estimates of LGM productive estimates, Westley and Dix 2008 views our hypothesis as unlikely but concludes that the LGM paleoecological evidence has not been examined in enough detail to support or invalidate it.

48. Sancetta 1992.

49. See Stirling 1997; Gilchrist and Robertson 2000.

50. Chapman and Shackleton 1998.
51. Chapman and Maslin 1999.
52. See, e.g., Butzer 1986.
53. Chapman and Shackleton 1998.
54. Jensen 1944.
55. Dyke et al. 2002.
56. Bond et al. 1992.
57. See, e.g., Broecker 1994.
58. See, e.g., Sancetta 1992.
59. Abrantes 1991.
60. Clottes and Courtin 1996.
61. Fuller 1999.

10. LIVING ON THE ICE EDGE

1. Beyond the personal experience Dennis gained during his years of working in the Arctic, the information on Arctic hunting and survival in this chapter is taken from the following sources: Oozeva et al. 2004; Krupnik 1993; Steinbright 2001; Nelson 1969. We are especially indebted to Richard Nelson, whom Dennis first met on the frozen Beaufort Sea near Point Barrow, Alaska, some forty years ago. We draw on Nelson's deep knowledge of Inuit ice hunting to provide practical insights into the probability of successful Paleolithic voyages on the ice age oceans.
2. For the latest reconstruction of the extent of sea ice during the LGM, see de Vernal et al. 2006.
3. Modern trash caught in the oceanic gyres is an environmental hazard, but Ebbesmeyer and Scigliano 2009 gives a fascinating account of how human drifters, lost tennis shoes, messages in bottles, and other non-oceanic debris have helped researchers to document their size, velocity, and orbital speed.
4. See Byock 2001 for the cultural conflicts and legal infrastructure related to driftwood in early Icelandic society.
5. Montenegro et al. 2006 suggests that during the LGM westward winds were stronger and eastward winds weaker than present-day winds.
6. D. N. Thomas 2004 is an excellent non-technical source of information on the formation, conditions, and rich biotic habitats of pack ice.
7. Hough 1898.
8. The adventurer Tim Severin, to test the possibility that the sixth century Irish monk St. Brendan had successfully sailed an open skin boat from Ireland to Newfoundland, researched and built such a boat to re-enact the legendary journey. After a false start with a relatively inexperienced crew, he signed on a Faroese fisherman, Trondur, who was well versed in problems related to ice and survival on the North Atlantic. It took only fifty days to make the crossing, and the boat remained in the water for those eight weeks. For additional fascinating details, see Severin 2000.
9. Maggs et al. 2008.
10. See Straus 1979; Straus and Clark 1986.

11. Additional evidence of the Solutrean use of marine and freshwater fish can be found in Morales-Muñiz and Roselló-Izquierdo 2009.
12. For an excellent summary of the early developments of watercraft in the Pacific, see Kirch 2000. See also Erlandson 2001; O'Connor and Veth 2000.
13. Oda 1990. See also A. Anderson 1987.
14. It is likely that Crete was never connected to the mainland, but some researchers assume continental bridges existed from time to time. See Facchini and Giusberti 1992.
15. D'Errico 1984.
16. Fuller 1999.
17. Otte 2002. But cf. Straus 2001.
18. Renfrew and Aspinall 1987.
19. Excavation: Simmons 1988; controversy: Bunimovitz and Barkai 1996.
20. C. M. Smith and Haslett 2000. On these boats' technical details, see Roberts 1995.
21. Chronicled in the *Relación Sámano-Xeréz,* cited in Edwards 1965.
22. Bergen, Niekus, and Vilsteren 2002.
23. Zunig 2002.
24. Casson 1994.
25. Aikens and Higuchi 1982.
26. Lee and Robineau 2004.
27. See McCartney and Veltre 1996 for the latest summary of the archaeology of Ananiuliak Island.
28. Dixon et al. 1997.
29. See Orr 1962; J. Johnson et al. 2000.
30. Erlandson et al. 1997.
31. See Erlandson et al. 1996; Erlandson et al. 1999.
32. Holland 1999.
33. S. Loring, personal communication.
34. Loring 1980.
35. See Jodry 2005; Morris and Goodyear 1973; Yerkes and Gaetner 1997.
36. Wheeler et al. 2003.
37. See, e.g., Straus 2000.
38. Krupnik 2005.
39. Chesemore 1975.
40. Lehn 1979.

CONCLUSION

1. Prudden 1903.
2. Schurr 2004.
3. Reidla et al. 2003.
4. Izagirre and de la Rúa 1999.

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